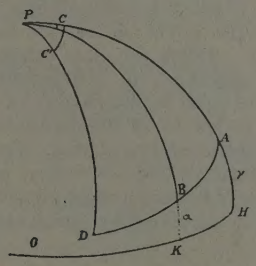
SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

SEPTEMBER 1900.

GENERAL PHYSICS.

1786. *Angular Measurement by Mirrors.* **A. Schuster.** (Phys. Zeitschr. 1. pp. 225-227, Feb. 17, 1900.)—In the optical measurement of angles it is assumed that the mirror is parallel to its axis of rotation. This cannot always be ensured, and it may happen that in a vertical suspension the mirror is inclined a degree or so to the vertical. Let O (see diagram) be the centre of the mirror, OP the axis of rotation, and OA the direction of the incident ray. If the normal to the mirror is originally in the plane OPA, and the mirror is deflected until its normal lies in OB, APB is the angle to be measured. Let



it be denoted by C. The reflected beam will lie in the plane OAB such that AB = BD. The angle APD (C′) is directly read from the scale, and we must now have an equation connecting C and C′. Let γ be the inclination of the incident beam, and α that of the mirror normal. Then since BD = AB = C, we have $\sin 2C \sin A = \sin PD \sin C'$, and eventually

$$\frac{2\sin(C'-C)}{\sin C'} = \frac{\cos\gamma}{\cos C \cos^2\alpha\cos\gamma + \sin\alpha\cos\alpha\sin\gamma}$$

in the most general form. For practical corrections the author gives the equation

$$dx = x\alpha(\gamma-\alpha)$$

to be added to the scale reading x. E. E. F.

1767. *New Curve-tracer.* **M. Dechevrens.** (Comptes Rendus, 130. pp. 1616–1620, June 11, 1900.)—This machine, which the author terms the campylograph, is an extension of the instruments constructed for the drawing of Lissajou's figures. Some of its features resemble those of the machine shown in 1889 by Rohn, but the two slotted rulers can be made to move quite independently of each other, with a large variety of velocity ratios. In addition, the support of the paper can be given a movement of rotation, which is then superimposed upon the ordinary figures. The author reproduces a variety of beautiful patterns. The instrument can also describe ellipses and parabolas. E. E. F.

1768. *Apparatus to measure Extension of Wires.* **G. F. C. Searle.** (Cambridge Phil. Soc., Proc. 10. pp. 318–323, May 7, 1900.)—Two similar wires side by side have at their ends small rectangular brass frames, 11 cms. long, the loads being placed below the frames. A sensitive level is placed between the two frames, resting at one end on a micrometer screw, which gives the lengthening of the wire stretched, and may be read to $\frac{1}{1000}$th mm. The apparatus has been used in the Cavendish Laboratory to investigate the deviations from Hooke's law for copper wire, well-marked hysteresis curves being obtained. It is shown, using G. A. Shakespear's results, that the error introduced by assuming that the coefficients of expansion of the two wires are identical under different stresses is quite negligible. G. E. A.

1769. *Method of Testing Weights.* **T. W. Richards.** (Zeitschr. Phys. Chem. 33. pp. 605–610, June 1, 1900).—The author describes a simple method of determining the corrections of weights which is based upon weighing by substitution. This has the advantage of eliminating a possible inequality in the arms of the balance, and avoiding the errors usually attending the change of weights from one arm to the other. The comparison begins with the centigramme weights, one of which is balanced by a counterpoise, after which the next centigramme weight is put on and the balance re-established by means of the rider. The weights are thus compared in succession, the gramme being balanced against all the centigrammes, and so forth. This gives a number of equations equal to the number of weights, less one. It is most convenient to suppose that one of the centigramme weights is correct, and to calculate all the others in terms of that. The result is that the larger weights have a disproportionately large correction, but that may be avoided by subsequently taking one of them as a standard and reducing the others to it, and the author gives an expedient by which this recalculation may be simplified. E. E. F.

1770. *Specific Gravity of Yttrium, Zirconium, and Erbium.* **S. Meyer.** (Akad. Wiss. Wien., S.ber. 108. pp. 767–770, 1899).—The element yttrium, which has been previously shown by the author to be paramagnetic, occurs in the periodic system among a series of diamagnetic elements. To ascertain whether it is situated in its proper position, the author determines the specific gravity of the three metals, yttrium, zirconium, and erbium, using a volumenometer specially adapted for use with powdered materials. The numbers found are: yttrium, 3·80; zirconium, 4·08; erbium, 4·77; the corresponding atomic volumes are hence 23·6, 22·6, and 34·9 respectively. The value for yttrium is hence in perfect accord with its position in the periodic system, and its abnormal magnetic behaviour must be ascribed to its admixture with some known or unknown element having an atomic weight lying between 140 and 180. T. H. P.

1771. *Density of Gases.* **R. Jahoda.** (Akad. Wiss. Wien., S.ber. 108. pp. 803–810, 1899.)—This paper describes some experiments on the comparison of densities of gases by the organ-pipe method. The pipes used were closed ones, one having a movable piston. The position of this piston for equality of frequency when the pipes are blown, one with air and the other with the gas, is a measure of the relative densities. A scale is fitted, and can be calibrated in densities. The following results are given :—

CO_2 1·521, Coal Gas 0·490, Water Gas 0·631, Oxygen 1·118.

The author has also used the method to determine the percentage of CO_2 in a mixture of gases. J. B. H.

1772. *Dust Nuclei.* **C. Barus.** (Science, 11. pp. 201–206, Feb. 9, 1900. Prelimin. Rep. of Work under Grant from Smithsonian Inst.)—Observations on the condensation of supersaturated steam obtained from jets, following the general method of colour tubes (U.S. Weather Bureau, Bull. No. 12, pp. 104, 1895). It is already clear that the velocity of diffusion of dust particles ejected from phosphorus by an oxygen reaction is independent of their density of distribution. The author still thinks condensation is always primarily due to nuclei, and that whether they are ionised or not is of secondary, perhaps negligible, consequence. The fine phosphoric dust travels with a definite velocity, is absorbed by surface, and liberated by heat; but it does not appear to be ionised. There is no noteworthy difference between the action of air carrying such dust and that of ionised air. On the other hand air bearing phosphoric dust will dissipate charges, as if the phosphorus when emitting dust emitted at the same time some form of obscure radiation. Sulphuric acid does not produce this effect. There is promise of a non-electric, purely optical method of measuring the individual velocity, and possibly the mass of the dust particles absolutely. A. D.

1773. *Viscosity of Sulphur at Temperatures above that of Maximum Viscosity.* **C. Malus.** (Comptes Rendus, 130. pp. 1708–1710, June 18, 1900.) Experiments made according to Gernez' method. Let

S_1 = sulphur which has been kept for 10 min. at 357° C.
S_2 = „ „ „ „ more than 3 hrs. at 357° C.
τ' = time spent in a state of superfusion (cooling bath).
Δ = time required for the solidification of a column of supercooled liquid sulphur one centimetre long.

The results of eighteen different experiments are summed up as follows: "The Δ of S_1 at 100° depends on the velocity and temperature of cooling. It decreases when τ' increases, and tends towards the value 5¼ secs., which it attains after five or six hours, and which it preserves indefinitely; S_1, at first viscous, has then become quite fluid. This limiting value of Δ is the value of the Δ of S_2 at 100° from the very beginning. S_2 is fluid from the start, and its Δ is independent of the velocity of cooling, the temperature of the cold bath, and the length of its sojourn therein (τ')."

Further experiments lead to the following conclusion: "Sulphur, when kept for a long time at 100°, loses its viscosity just as at 360° C, but the cause which operates in restoring the viscosity persists in the sulphur which has lost its viscosity at 100°, although it has disappeared from the sulphur which has lost its viscosity at 357°." F. G. D.

1774. *Diffusion (Transpiration) of Air through Water, and a Method of Barometry.* **C. Barus.** (Amer. Journ. Sci. 9. pp. 397–400, June, 1900).—The author proposes to study the rate at which a small volume of air escapes by diffusion through an enclosing wall of water. For this purpose he uses a small Cartesian diver. The paper is occupied with an account of a highly ingenious method for ascertaining the volume of air enclosed in the diver. Incidentally the author shows that the arrangement amounts to a water barometer of very short length. For the theory of this instrument reference must be made to the original paper. F. G. D.

1775. *Surface Tension and Viscosity of Liquid Air.* **C. Forsch.** (Phys. Zeitschr. 1. p. 177, Jan. 13, 1900.)—These are a few preliminary measurements intended for orientation only. The surface tension was measured by the method of capillary elevation, the capillary glass tube being immersed in liquid air under ordinary pressure. The surface tension came out at about 1·23 mg. per mm. Much of the nitrogen had already evaporated when the measurements were begun. The viscosity was measured by the method of efflux through capillary tubes. The coefficient of viscosity was found to be 0·0033 c.g.s. units at the boiling point of liquid air under ordinary pressure. E. E. F.

1776. *Superficial Tension.* **P. Dutoit** and **L. Friederich.** (Archives des Sciences, 9. pp. 105–132, Feb., 1900. Paper presented to University of Geneva, Jan., 1898.)—Ramsay and Shields' formula is that where a liquid rises to height h in a tube of radius r, d and a being the orthobasic densities of the liquid and of its saturated vapour, then its superficial tension in dynes per sq. cm. is $\frac{1}{2}rgh(d-a)=\gamma$; and then if M be the molecular weight of the liquid, and v its specific volume at temperature t, its superficial molecular energy is $\gamma(Mv)^{2/3}=k(t_c-t-d)$ where t_c is the critical temperature, d is a constant in value about 6, and k is about 2·12. The author finds a large number of cases in which k differs materially from 2·12. It rises as we ascend homologous series, as if the lower members of the series were feebly polymerised. It also varies with atomic groupings in the molecule. Ramsay and Shields' formula yields the following expression for the critical pressure. Taking the temperature such that $(t-d)=nt_c$ the formula becomes $\gamma(Mv)^{2/3}=t_c.k(1-n)$. Then we have approximately $Mv_cp_c=At_c$; whence $p_c=\gamma\sqrt[3]{Mv}\,A.Mv/Mv_c.\{k(1-n)\}^{-1}$, which, since Mv/Mv_c is constant if we adhere to corresponding volumes, is of the form $p_c=Q.\gamma\sqrt[3]{Mv}$. This enables critical pressures to be calculated within about one atmosphere. This expression is of the same order of exactness as Ramsay and Shields', from which it is derived. [See also Abstract No. 989 (1900)]. A. D.

1777. *Thickness of Transition Superficial Layers.* **G. Vincent.** (Journ. de Physique, 9. pp. 78–91, Feb., 1900; and Soc. Franç. Phys., Bull. 142. p. 5, Jan. 19, 1900. See also Annal. Chim. Phys. 19. pp. 421–432, March, and pp. 433–516, April, 1900.)—Superficial films, at the bounding surfaces of solids or liquids, might or might not appear to have different thicknesses according to the physical properties by means of which we explore them. Experiments of Reinold and Rücker and Quincke are summarised. The author finds that films of silver upon glass, if the thickness exceed 50×10^{-7} cm., are composed of a homogeneous layer of constant specific conductivity, and two superficial layers of constant thickness, whose conductivity is smaller but

fixed; and that the joint thickness of these two superficial layers is about 50×10^{-7} cm. Quincke's results are in agreement with this, and show that the action between the silver and water becomes constant as soon as these superficial layers are completely formed, and that the core takes no part in this action, nor yet the superficial layer on the glassward side. It is not necessary to conclude that the thickness of the superficial layer is equal to the radius of molecular activity: the latter might be, say, one-half the former; but it cannot exceed it. All the methods of experiment give data of the same order for the thickness of the transition superficial layers, about 25×10^{-7} cm. for each surface. A. D.

1778. *Transition Layers and Molecular Action.* **G. Quincke.** (Ann. d. Physik, 2.2. pp. 414–420, June, 1900.)—The author combats the idea put forward by G. Vincent that a thin silver surface is bounded on both sides by "transition layers" of a different constitution from the rest of the metal. He attributes the variation of the specific resistance to a variation of the density, and adheres to his opinion that the radius of molecular action is about 50 mm. Liquids are in many ways unsatisfactory for use in determining molecular forces. In soap bubbles and solutions generally, the constitution of the liquid film is not uniform. In soap bubbles the soap goes to the surfaces and the water remains in the central layer, so that one really has to do with three layers. In liquid layers of diameter less than twice the radius of molecular action, the change of density at the surface depends upon the time during which expansion takes place and the time during which the molecular forces of adhesion act upon the liquid particles. The changes of density involve other physical and chemical changes as well, and these also change with the time. Wedges of solid material are therefore preferable in all such determinations. E. E. F.

1779. *Anemometer Tests.* **C. F. Marvin.** (Monthly Weather Rev. 28. pp. 58–63, Feb., 1900.)—When testing anemometers in 1888 against a very large whirling machine with a radial arm 35 feet in length, placed in a closed court, the author obtained concordant results, but the same anemometers differed when compared in open air. The reason is that every natural wind is gusty, and a steady and a gusty air current affect an anemometer in a different manner on account of the inertia. In May, 1899, he installed a new whirling machine at Arlington, Va., in the open air. The radial arm, bearing the anemometer under test at its extremity, had a length of 28 feet, and the natural wind velocity was determined with the aid, first of an axial anemometer, and then by an anemometer fixed on an independent pole close to the apparatus. The machine was turned by hand or steam, the maximum circumferential speed being 60 miles an hour. It might be thought that a natural wind would neither accelerate nor retard the movements of the best anemometer with this arrangement. It is demonstrated, however, that there is always a gain in speed. The recording instruments comprised a battery, a seconds pendulum, an Alvan Clark astronomical chronograph with two pen carriages, and a telegraphic sounder to give audible signals that everything was in order. The five anemometers tested were a set of aluminium cups, 4 inches in diameter, 9·5 ozs. in weight; two small kite anemometers, 1·22 inches in diameter, weighing about 0·8 ozs.; and two sets of paper cups, about 4 inches in diameter, and weighing 1·8 and 1·7 ozs.; the length of arm to cup centre was 6·6 inches, and in one case 2 in. The resulting anemometer

speeds are slightly lower than those formerly obtained, and on the whole the open air tests confirm the previous experiments. Tilting the anemometer axis did not seem to have much effect; but the apparatus was not suited for such experiments. H. B.

1780. *Cloud Observation in U.S.A.* **F. H. Bigelow.** (Monthly Weather Rev. 28. pp. 8–12, Jan., 1900; from the Amer. Journ. Sci. Dec., 1899.)—Observations were made by the U.S. Weather Bureau from May, 1896, to June, 1897, in the primary base station at Washington and at fourteen nephoscope stations distributed uniformly east of the Rocky Mountains. The 6,600 single theodolite and 25,000 nephoscope observations have been utilised to establish a standard system of constants and formulæ, and to compile new tables concerning cloud strata up to elevations of 15,000 m. and temperatures varying, for the several strata, between $-60°$ and $+40°$ C. For the reduction of the barometric pressure B to the sea-level value B_0, the usually employed formula $B_0 - B = B(10^m - 1)$, in which m is a function of temperature, humidity, gravity, altitude, and surface topography, is less convenient than $\log B_0 = \log B + m - \beta m - \gamma m$, where β refers to humidity and γ to gravity. In cloud formation we have to distinguish between the saturated, unsaturated, freezing, and frozen stages; and further, as regards the ratio of vapour pressure e to barometric pressure B, between true adiabatic saturation e/B and actual e_1/B_1. The kite ascensions of 1898 permit of doing this. The paper discusses briefly the problem, how much heat should be added to an ideal adiabatic atmosphere to produce the actual atmosphere in its several layers, and the motions of the atmosphere with special regard to cyclones which are formed in large numbers on the North-American continent and dissipate in Europe and Asia. The author questions the ordinary canal circulation theory, which assumes a southward movement from the poles in the lower strata with a reversal of the component from east to west at lat. 35°, and an overflow northward on the higher strata. In each stratum about as much air moves north as south, for there are enormous counter currents passing by each other at the same level, and not over one another at different elevations. The solar energy is absorbed chiefly in the lower strata, and a continuous leakage is developed in the lower strata, which is observed as our persistent winds from the south. This escape from the tropical belt diminishes the pressure in low latitudes which would require to be balanced by an excessively rapid eastward drift. The formation of cyclonic vortices discharging into the eastward drift and distorting it also retards the eastward velocity. H. B.

1781. *Polarisation of Corona, May* 28, 1900. **P. Joubin.** (Comptes Rendus, 130. pp. 1597–1599, June 11, 1900.)—The author, observing at Elche, on the east coast of Spain, used a telescope with terrestrial ocular, in conjunction with (1) a biquartz, (2) a *single wave* plate, and a nicol placed between the components of the ocular. No effect was noticed from the solar equator to a point about 15° or 20° from the solar north pole; near here, however, slight traces of elliptic polarisation were discernible. C. P. B.

REFERENCE.

1782. *Spectrographic Eclipse Results, Jan.*, 1898. **W. W. Campbell.** (Astrophys. Journ. 11. pp. 226–233, April, 1900.)—This paper contains detailed particulars of apparatus used and photographs obtained during the total eclipse of the sun in India, 1898. [See also Abstract No. 456 (1900)]. C. P. B.

LIGHT.

1783. *Electromagnetic Illustration of the Theory of Selective Absorption of Light by a Gas.* **H. Lamb.** (Cambridge Phil. Soc., Trans. 18. pp. 349–363, April, 1900.)—The subject of the scattering of waves by an insulated sphere has been treated by Rayleigh, Love, and G. W. Walker, always on the hypothesis that K, the dielectric constant of the sphere, is not very great. The present writer calls attention to the case in which K is a very large number. On this hypothesis two modes of free oscillation are possible whose wave-lengths in the surrounding medium are large compared with the periphery of the sphere, and which in general give rise to slow dissipation by the scattering of the waves. But when extraneous waves whose period is nearly coincident with that of a free oscillation encounter the sphere the divergent waves attain abnormal intensity.

A molecule being conceived as a sphere of this nature the author develops the theory mathematically. The results as stated by himself are principally as follows: For every period of free vibration there is a period, nearly coincident with it, of maximum dissipation for the incident waves. When the incident waves have precisely this period the rate of dissipation is, in terms of the energy flux of the primary waves, $\frac{2n+1}{2\pi}\lambda^2$, where λ is the wave-length and n the order of the spherical harmonic which is effective. Some results of this relation are pointed out. It is observed that a very minute change of λ enormously reduces the scattering. S. H. B.

1784. *Monochromatic Vision.* **W. de W. Abney.** (Roy. Soc., Proc. 66. pp. 179–180, April, 1900.)—An account of a case of monochromatic vision. The patient's luminosity curve is given. All colours he matched with white with the same facility as if they were white. The luminosity curve agrees very nearly with that of a similar case previously described, and attention is called to the fact that these curves are practically identical with those obtained by the normal eye when it measures a spectrum of very feeble luminosity, and also agree with the results obtained by measuring the diminution of each ray when it first becomes invisible, and making a curve of the reciprocals of the numbers. J. J. S.

1785. *Temperature Control of the Mills Spectrograph.* **W. W. Campbell.** (Astrophys. Journ. 11. pp. 259–261, May, 1900.)—After considering the great importance of securing uniformity of temperature of the spectrograph used in determinations of the velocity of stars in the line of sight at the Lick Observatory, the author describes the precautions he has adopted to secure these conditions. The instrument is encased in a double covering of woollen blanket, and then the whole enclosed in a cedar box lined with hair felt. In this box is distributed a length of German silver wire, connected with a rheostat and battery, by the regulation of which any variations of temperature may be at once corrected. The value of the installation is admirably shown by a table of the thermometer readings during an actual night's work of eight hours. While the temperature in the dome varied from 17·9° C. to 19·0° C., the extremes in the wooden box were 18·4° and 19·0°, and in the prism-box itself only 18·70° and 18·84°. C. P. B.

1786. *Ultra-Violet Absorption.* **B. Glatzel.** (Phys. Zeitschr. 1. pp. 285–287, March 31, 1900.)—The author determines absolute absorption co-efficients in the ultra-violet by means of Vierordt's double-refracting spar. The substance is put into a quartz trough and placed in front of one of the slits of the spar. Comparison of the two luminosities is made by photography, and the co-efficient of absorption is given by

$$a = -\frac{1}{d}\frac{\log \frac{i}{i'}}{\log e}$$

where d is the thickness of the film in mm., and i/i' the ratio of the

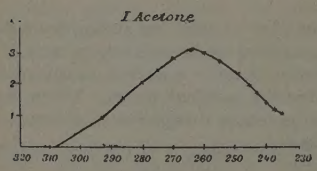


Fig. 1.

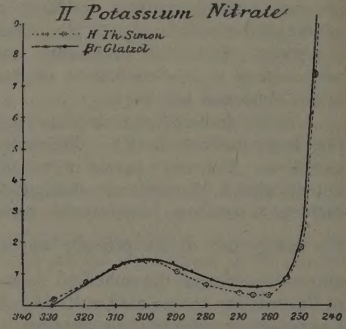


Fig. 2.

intensities. The diagrams embody the results for acetone and potassium nitrate, the latter being compared with the results given by H. T. Simon. E. E. F.

1787. *Curvature of Spectral Lines in Spectroheliograph.* **W. S. Adams.** (Astrophys. Journ. 11. pp. 309–311, May, 1900.)—The use of a prismatic spectroheliograph for the Yerkes telescope necessitated a determination of the amount of curvature of the spectrum lines, so that the jaws of the slits could be properly made. The distortion in this case was specially great, as the slit had to be nearly *eight* inches in length to take in the whole of the solar image as projected by the 40-inch lens. After deducing the formula of curvature for a two-prism train, calculated and measured values of the distortion are given in a table. C. P. B.

1788. *Specific Rotation of Sugar.* **O. Schönrock.** (Zeitschr. Instrumentenk. 20. pp. 97–113, April, 1900. Mittheilung aus der Physikalisch-Technischen Reichsanstalt.)—This is an accurate investigation of the temperature coefficient of the specific rotation of various kinds of sugar. The specific rotation is defined by the equation—

$$[\alpha]_t = \frac{100\alpha_t}{l_t \rho d_t}$$

where α_t is the rotation in degrees, l_t the length of the tube in decimetres, d_t

the density, and p the percentage of sugar in solution. The dependence upon the temperature is represented by the equation—

$$[\alpha]_t = [\alpha]_{20}\{1-\delta(t-20)\}$$

where δ is the temperature coefficient. This was found to vary between 0·000202 and 0·000232. The final formula for a nearly normal sugar solution is—

$$[\alpha]_t^D = [\alpha]_{20}^D - [\alpha]_{20}^D\, 0{\cdot}000277(t-20).$$

E. E. F.

1789. *Zeeman Effect.* **A. Righi.** (N. Cimento, 11. pp. 177–206, March, 1900. Mem. della R. Accad. di Bologna, December 17, 1899. Écl. Électr. 23. pp. 356–366, June 9, 1900.)—This is a theoretical and experimental investigation of the general case in which an angle ϵ of any value between 0° and 90° lies between the direction of the ray and the magnetic field which influences it.

For $\epsilon = 90°$ every ray emitted gives a triplet. The middle component is due to vibrations parallel to the lines of force, and its intensity is double that of the lateral components. The latter are due to vibrations normal to the field. When ϵ diminishes, the middle component also diminishes in intensity, but retains its state of polarisation. At the same time the brightness of the lateral components increases, and their vibrations become elliptical, in opposite senses, with their major axes normal to the meridian plane. When $\tan \epsilon = \sqrt{2}$, and $\epsilon = 54° 44'$, the three components of the triplet have equal intensities. When ϵ becomes still smaller, the middle ray diminishes further in brightness, while the brightness of the others increases. For $\epsilon = 0$ the middle ray disappears, while the lateral ones acquire their maximum intensity and are circularly polarised in opposite directions. All these changes are predicted theoretically by Lorentz's theory, or indeed by any theory which admits the existence, in a magnetic field, of a rotation about the lines of force of the medium in which the luminous vibrations have their seat. They are also fully verified experimentally. In the case of quadruplets, like the 4,800 cadmium line and the 4,722 zinc line, the two central components behave like the ordinary single component, and the outer components like the ordinary lateral components.

The author also verifies the theoretical data with respect to the Zeeman phenomenon as seen by absorption. No triplets are available for this verification, as no very fine triplets can be had. The author therefore employs the green ray of thallium, 5,351, and D_1, which give quadruplets, and D_2, which gives a sextuplet. As long as ϵ is greater than zero, D_1 and the thallium line give a quadruplet. As ϵ diminishes from 90° the two middle rays become less black and the external rays become more marked. Their behaviour is in fact strictly analogous to that of the normal triplet in the emission effect. In the matter of polarisation also, the lateral components show the circular and elliptical polarisations already described, as can be shown by means of a quarter-wave plate, which makes the right or left-hand component disappear according as it is right-handed or left-handed. In the sextuplet, the two outer pairs of lines behave like outer components of the normal triplet.

E. E. F.

1790. *The Law of Complete Radiation.* **Rayleigh.** (Phil. Mag. 49. pp. 539–540, June, 1900.)—By complete radiation is understood radiation from an ideally black body, which according to Stewart and Kirchhoff is a definite

function of the absolute temperature θ and the wave-length λ. The energy of that part of the spectrum which lies between λ and $\lambda + d\lambda$ should be of the form $\theta^5\phi(\theta\lambda)d\lambda$ according to Boltzmann and W. Wien, and according to Wien's later result, $c_1\lambda^{-5}\epsilon^{-c_2/\lambda\theta}d\lambda$. The author suggests, from considerations connected with the law of partition of energy, a modification of the above, namely, $\theta\lambda^{-4}d\lambda$ instead of $\lambda^{-5}d\lambda$, but leaves the question to be settled by experiment. S. H. B.

1791. *Anomalous Dispersion in the Faraday Effect.* **A. Schmauss.** (Ann. d. Physik, 2. 2. pp. 280–294, June, 1900.)—The author tests whether the magnetic-rotatory dispersion in substances showing anomalous optical dispersion also shows discontinuities in the neighbourhood of the absorption bands. The substances examined were fuchsine and cyanine dissolved in alcohol; didymium glass, and the fluorescent dyes, eosene and naphthaline red. Rather dilute solutions were employed, so as to be able to follow the existing anomalies into the absorption bands themselves. Wiedemann's method was employed, but with the addition of an aragonite crystal, so that the rotation was indicated by the position of the area devoid of interference fringes. These fringes could be plainly made out within the absorption bands themselves when the latter were not too dark.

The results show that the general form, which Kundt gave to the law of optical dispersion, can also be applied to the dispersion observed in the Faraday effect. Proceeding from the red to the violet, the rotation increases very rapidly just before the absorption band is reached, decreases rapidly within it, and increases again after the band is passed. In strongly absorbing media the anomalous dispersion extends over a considerable region on both sides of the absorption band, and the anomaly increases with the concentration. It also increases with the sharpness of the absorption band. The rapid rise of the curve of rotatory dispersion in ordinary media is due to the existence of an absorption band in the ultraviolet. The anomalies observed are so considerable that they form a useful criterion for the existence of an absorption band where the eye is incapable of perceiving it. Thus, according to Vogel, cyanine shows a slight absorption between D and E in an aqueous solution, but not in an alcoholic solution. The author found indications of an absorption band in his alcoholic solution of cyanine, and was able to trace it to a slight admixture of water in the commercial "absolute alcohol" used. E. E. F.

1792. *Band Spectrum of Aluminium.* **G. A. Hemsalech.** (Ann. d. Physik, 2. 2. pp. 331–334, June, 1900.)—The author describes some experiments which confirm Aron's view that the band spectrum of aluminium is due to the metal itself, and not to the oxide. With the ordinary induction spark the bands are not obtained very clearly if the gap is large. On introducing a condenser, the bands are obscured by the very bright line spectrum of the air, which with aluminium electrodes comes out very prominently. If the spark is made horizontal, and its image is projected on to the slit of a spectroscope, the air spectrum and the high-temperature aluminium lines appear in the middle, and the band-spectrum above and below. The air spectrum can be eliminated by introducing an inductance coil without iron core, and then the bands appear in great intensity. These bands are also seen when the spark passes in an atmosphere of hydrogen or nitrogen. The bands are most vivid in oxygen, because then the spark is strongest, and vapour is freely evolved. In none of the cases do the electrodes show any sign of oxidisation. E. E. F.

1793. *Influence of Impurities upon Gaseous Spectra. II.* **P. Lewis.** (Ann. d. Physik, 2. 3. pp. 447–458, July, 1900.)—Having previously studied the effect of admixtures of mercury, water vapour, and oxygen upon the spectrum of hydrogen [see Abstract No. 468, 1900], the author proceeds to study the effect of the same impurities upon the spectrum of nitrogen. This is reduced by the presence of mercury, but not in such a pronounced and regular manner as is the hydrogen spectrum. Oxygen brings about a general reduction of intensity, while water vapour in any considerable quantity suppresses the red, yellow, and green bands entirely, and reduces the blue bands. E. E. F.

1794. *Absolute Determination of Spectrum Wave-lengths.* **L. E. Jewell.** (Astrophys. Journ. 11. pp. 234–240, April, 1900.)—This is a reply to a statement made by E. B. Frost [see Abstract No. 457, 1900] that the effect of the rotation of the earth on its axis, and the eccentricity of the earth's orbit, upon the wave-lengths of the lines of the solar spectrum, had never been taken into consideration. The corrections due to these causes, however, are so small that it is useless to apply them to determinations in which the errors of observation are considerably greater. C. P. B.

1795. *Titanium for Comparison Spectra.* **L. E. Jewell.** (Astrophys. Journ. 11. pp. 243–244, April, 1900.)—E. B. Frost has previously pointed out the convenience of using the spark spectrum of titanium as a standard for comparison with stellar spectra. [See Abstract No. 56, 1900.] The present author points out its occurrence in the spectrum of the solar chromosphere, the lines at λλ3685·339, 3759·447, 3761·464 being specially prominent. C. P. B.

1796. *Luminosity Curve of Solar Spectrum.* **D. W. Murphy.** (Astrophys. Journ. 11. pp. 220–225, April, 1900.)—The author commences by stating the difficulties involved in photometric comparisons of lights of different colours, enhanced by individual personal error. His own work has been done with a Lummer-Brodhun spectrometer, and part of the difficulty of colour contrast eliminated by making the comparisons between small portions of the spectrum very close to each other, the difference in tint being thereby a minimum. The most constant source of illumination was found to be the open sky during June and July. After adjusting the two comparison spectra to equality, the movable collimator, having a slit of constant width (0·25 mm.) was moved in progressive steps of an angular value equal to that subtended by this slit width, thus bringing successive small portions of the spectrum into comparison with the standard. The varying widths of the other slit necessary to produce equality of intensity were then noted. In this manner the spectrum was measured from λ 6880 to λ 4500, and the results are given in two tables and also plotted as curves. C. P. B.

1797. *Production of Röntgen Rays by a Battery Current.* **J. Trowbridge.** (Amer. Journ. Sci. 9. pp. 439–441, June, 1900.)—The author has lately completed the installation of a plant of 20,000 storage cells in the Jefferson Physical Laboratory. This places at his disposal an E.M.F. of over 40,000 volts, and a comparatively steady current through a large resistance. He has succeeded in obtaining Röntgen rays of exceptional brilliancy with the aid of this E.M.F., which, moreover, yield negatives of great contrast, showing traces of the shadows of ligaments and muscles. The great advantage of this new method of generating the rays is the possibility of exactly regulating the

current and difference of potential which is necessary to excite the rays. This is not possible by any of the methods hitherto used. When the Röntgen ray tube is first connected to the battery terminals no current flows; it is necessary to heat the tube with a Bunsen burner. At a certain critical temperature the tube suddenly lights up with a vivid fluorescence, and the rays are then given off with great intensity. The author employed a distilled-water resistance of about 4,000,000 ohms. This places it beyond a doubt that no electrical oscillations had any part in the production of the Röntgen rays. E. E. F.

1798. *Diffraction of Röntgen Rays.* **A. Sommerfeld.** (Phys. Zeitschr. 1. pp. 105–111, 1899.)—Mathematical discussion of the theory of single impulses at irregular intervals: applicable also to a certain extent to noises in the theory of sound. A peculiar wave-form is traced out and illustrated. Shadows are absolutely sharp for infinitely short impulses: in other cases there is a certain amount of diffraction, but at the shadow boundary there is no succession of maxima and minima as in optics, but a steady fall off, more or less steep. The shorter the impulses the less the absorption: so that the Röntgen rays best adapted for radiography are the worst adapted for the study of diffraction. The more deliberate impulses associated with lower vacua and correspondingly smaller velocities of the kathode rays would be better for diffraction-phenomena: those in the highest vacua should show none. The amount of diffraction is so related to the spread of disturbance upon the anti-kathode surface during the impulse that a table could be drawn showing the values of the latter corresponding to observed values of the former as shown by the photographic plate. The amount of diffraction observed by Haga and Wind [Amsterd. Acad., April, 1899, p. 420; Wied. Ann. 68. p. 884, 1899; Abstract No. 1871 (1899)] corresponds to a spread of $\frac{1}{3}$ 10^{-7} cm. from the centre during the impulse. This datum is not in disaccord with Lord Kelvin's estimate of the diameter of molecules if we take into account J. J. Thomson's result, that the spread of the impulse must be not less than the diameter of the molecule and is only in a limiting case so small as to be merely equal to it. A. D.

1799. *Diffusion of Röntgen Rays through Solids.* **H. Dufour.** (Phys. Zeitschr. 1. pp. 202–203, Feb. 3, 1900.)—When the base of an oblique prism of wood is exposed to Röntgen rays, photographic effects can be obtained from the opposite end, although that end may not be at all in the direct line of the rays. The effects are then due to secondary rays diffused in all directions through the body of the wood, and emerging in a diffused manner from the whole of its surface. The same effect may be obtained from paraffin and also from troughs filled with petroleum or some other liquids. The secondary rays emerge from the other surfaces, including those which are normal to the direction of incidence. E. E. F.

1800. *Röntgen Rays and Evaporation.* **E. Pasquini.** (N. Cimento, 11. pp. 133–135, Feb., 1900.)—The author finds no appreciable effect produced by Röntgen rays in influencing evaporation. A. D.

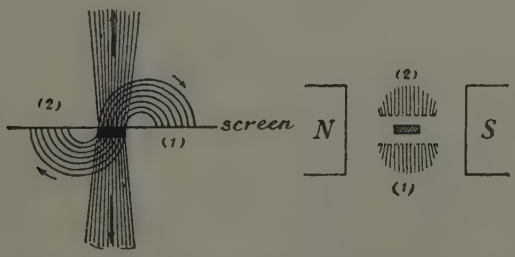
1801. *Duration of Röntgen Radiations.* **B. Brunhes.** (Comptes Rendus, 130. pp. 1007–1010, April 9, 1900.)—Further experiments, of the Wheatstone and Arago type. The period of emission under a spark is of the order of the ten-thousandth of a second. Traversing 35 cm. of air does not appear to affect the length of the train of waves; kathode rays behave differently. A. D.

1802. *Radiations of Radio-active Bodies.* **M. and Mme. Curie.** (Soc. Franç. Phys., Bull. 145. pp. 3–4, 1900.)—At the temperature of liquid air, radio-active bodies continue to excite fluorescence in uranyl-potassium sulphate. Radiferous $BaCl_2$ becomes more luminous at that temperature. Those radiations from radium which are not deviable in a magnetic field do not travel more than 7 cm. in air. Polonium only emits non-deviable rays, and these can only travel 4 cm. in air. Giesel's polonium, on the contrary, emits both deviable and non-deviable rays. The rays from radium carry negative charges, which cannot, however, be detected if air be the medium, since this is rendered conductive by the rays. These charges are small; about 10^{-11} coulombs per second from 2·5 sq. cm. of radiferous chloride of barium. A. D.

1803. *De-ionisation of Air.* **E. Villari.** (Accad. Lincei, Atti, 9. pp. 288–295, May 6, 1900.)—Air ionised by Röntgen rays loses its conductivity more rapidly when passing through a twisted metallic tube than the same length of a straight tube. It may be rapidly de-ionised by passing it through a bundle of copper wires. The tubes which de-ionise the air often take a high positive charge, which may attain an E.M.F. of some 40 volts. E. E. F.

1804. *Secondary Röntgen Rays.* **J. S. Townsend.** (Cambridge Phil. Soc., Proc. 10. pp. 217–226, Jan., 1900.)—The secondary radiation which extends to a distance from the body emitting it does not come directly from the surface but must be considered as emanating from the substance of the material. There is also another radiation rapidly absorbed by the gas near the surface of the radiating body; at atmospheric pressures the effect of this radiation is hardly appreciable at distances greater than 5 mm. from the surface. The latter radiation gives rise to Perrin's surface effect; the former produces ionisation at a distance. The rate of absorption of radiation by a gas appears proportional to the ionisation. The number of ions produced in a given volume is $S \times p\,D$, where S is the effect of the surface rays, p the pressure, and D a constant depending on the direct rays. When the pressure is reduced the absorption of the secondary rays is reduced proportionally, so that the surface rays come to extend across the vessel containing the gas, part of their energy then being absorbed by the opposite wall. A. D.

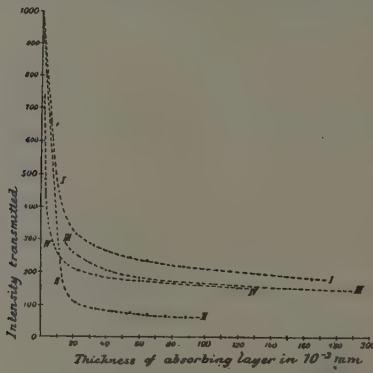
1805. *Radium and Polonium Rays.* **S. Meyer** and **E. R. v. Schweidler.** (Phys. Zeitschr. 1. pp. 90–91, and 113–114, 1899.)—The molecular magnetic



susceptibility of one of Giesel's radium preparations is found to be $-0{\cdot}08 \times 10^{-6}$, a value which is so near the value for pure barium chloride that no conclusion can be drawn as to the magnetic properties of pure radium, supposing

such a substance to exist. The radiation of the same preparation is considerably enfeebled by a magnetic field whose lines are at right angles to the electric lines of force, the radiation amounting to some 80 per cent. in a field of 17,000 units. Under the same circumstances, a radium preparation by Curie only shows a radiation amounting to 15 per cent., and polonium preparation none at all. This magnetic effect has more recently been explained as due to the magnetic deflection of the rays in question. The authors describe deflection effects similar to those attained by the Curies and by Becquerel. Thus, in a magnetic field due to the poles N.S., the radium rays produce two luminous patches, one on each side of the centre line joining the poles, and due to the curving round of the rays ordinarily proceeding upwards and downwards (see diagram). E. E. F.

1806. *Absorption of Radium Rays.* **S. Meyer** and **E. R. v. Schweidler.** (Phys. Zeitschr. 1. pp. 209–211, Feb. 10, 1900.)—In order to investigate the various degrees of absorption undergone by radium rays from different sources (see preceding Abstract), the authors examined the absorptivity of a number of metals for the rays from a radia-active barium chloride and bromide prepared by Giesel, and a carbonate prepared by Curie. The transmissions are plotted in the annexed diagram, where curve I gives the luminosities transmitted by tin in the case of Curie's preparation, III by palladium, IV by platinum, and II the tin curve of Giesel's preparations. It will be seen that the first few hundredths of a mm. are the most effective in the absorption, and



it may be concluded that in the case of radium rays, as in Röntgen, uranium, and thorium rays, the radiation consists of a large number of rays of different nature. The absorptions were measured by the electroscope method, and can therefore not be directly applied to other effects such as fluorescence or photographic action. The connection between fluorescence and electric ionisation is very irregular. Substances cannot be arranged according to their absorptive powers, as they vary with the thickness. For a thickness of 50×10^{-3} and Curie's preparation, the succession is: paper, aluminium, tin, copper, palladium, platinum. E. E. F.

1807. *Radiations from Radium.* **H. Becquerel.** (Comptes Rendus, 130. pp. 809–815, March 26, 1900.)—M. and Mme. Curie have shown that the

radiations from radium carry negative electric charges. They therefore, like kathode rays, probably depend on the transport of matter. Measurements of the electrostatic deviation in a magnetic field are difficult ; details are given. From the results of these measurements, with calculations of the trajectories, it appears that the velocity $v = 1{\cdot}6 \times 10^{-10}$, and the mass charge ratio for the molecules, m/e, $= 10^{-7}$, quantities of the same order as in the case of kathode rays. And on taking into account M. and Mme. Curie's value for the rate of loss of charge, it follows that the energy radiated per sq. cm. is about 5 ergs per second and the quantity of matter lost per sq. cm. is about one milligramme in a milliard years. A. D.

1808. *Radium Radiations.* **H. Becquerel.** (Comptes Rendus, 130. pp. 979–984, April 9, 1900.)—It appears that on traversing aluminium or black paper these radiations retain their velocities and their charges, or at least that the product mv/e varies little ; though there are some phenomena which point in a contrary direction. A. D.

1809. *Radium Radiations.* **H. Becquerel.** (Soc. Franç. Phys., Bull. 148. p. 4, May 4, 1900.)—Radium radiations are of three kinds—a part deviable by a magnetic field ; a part non-deviable and readily absorbed ; and a part weaker and diffused, non-deviable, attributable partly to secondary rays. A. D.

1810. *Radium Radiation at Low Temperatures.* **O. Behrendsen.** (Ann. d. Physik, 2. 2. pp. 335–337, June, 1900.)—The activity of a radium preparation was tested at ordinary temperatures, and at the temperature of liquid air, by the electrometer method. It was found that the cooling of the preparation reduced its radio-activity by more than one-half. On heating it up again to the normal temperature, a slight increase of radio-activity was discovered. This is quite in agreement with the behaviour of phosphorescent bodies as described by Lumière. The author also remarks that the polonium sublimates prepared a year ago have lost a considerable part of their radio-activity. Giesel makes the same remark concerning his own polonium preparations. E. E. F.

1811. *Uranium Radiation.* **H. Becquerel.** (Comptes Rendus, 130. pp. 1583–1585, June 11, 1900.)—Two different kinds of Becquerel rays have up to the present been discovered. One kind has practically all the characteristics of kathode rays, and is deflected by both magnetic and electric forces. The other kind is not deflected by either, and shows various degrees of absorption by metals and other opaque substances. Radium emits both kinds of rays. Polonium only emits the second kind, while Debierne's "actinium" only emits kathode rays. The author endeavours to determine the exact nature of the rays emitted by uranium, the first substance which was found to emit the rays named after him. The difficulty of operating with uranium lies in the feebleness of its radiation. He found, however, that the rays emitted were deflected to about the same extent as the most penetrating radium rays. That might be explained by the supposition that uranium contains an admixture of radium, and that the true uranium rays are feebler. But the author believes that these deflected rays are due to actinium. They can be removed by treating the uranium chloride with barium chloride. Radio-active barium sulphate is produced, and a purified uranium salt remains. Further purification makes no difference, and hence it is probable that uranium has a definite though feeble radiation of its own. E. E. F.

HEAT.

1812. *Specific Heat of Wheat-Starch as a Function of its Water-content and of the Temperature.* **H. Rodewald** and **A. Kattein.** (Zeitschr. Phys. Chem. 33. pp. 540–544, June 1, 1900.)—The method of measuring the specific heat is that formerly described by Rodewald, the starch being contained in sealed tubes of Jena glass. For starches containing different quantities of water the following are the specific heats calculated on the dry substance :—

Percentage of water ...	0	9·38	15·79	18·52	29·26	33·66
Specific heat	0·2697	0·2579	0·2603	0·2580	0·3081	0·3054

The temperature-coefficients of the specific heats are also given. These results show that no such relation exists for starch as was found by Volbehr for wood-fibre, the specific heat of which changes proportionally with its water-content and with the temperature. T. H. P.

1813. *Volume and Pressure of Saturated Vapour.* **H. Moulin.** (Comptes Rendus, 130. pp. 1454–1457, May 28, 1900.)—If ϵ is the difference between the coefficients of linear expansion of the molecule and its nucleus at constant pressure, and ϵ' the same under constant volume, and we put $\gamma = \epsilon T_c$ and $\gamma' = \epsilon' T_c$, the following formulæ may be obtained for the pressure and volume of any saturated vapour, as compared with those of a standard substance H—

$$\frac{v}{v_c} = \left(\frac{v}{v_c}\right)_H \left[1 + \gamma\left(1 - \frac{T}{T_c}\right)\right]^3$$

$$\frac{p_c}{p} = \left(\frac{p_c}{p}\right)_H \left[1 + \gamma'\left(1 - \frac{T}{T_c}\right)\right]$$

The author verifies these formulæ for a number of organic substances, and finds γ always to lie within the limits 0·2 and 0·5. E. E. F.

1814. *Tension of Saturated Mercury Vapour.* **L. Cailletet, Colardeau,** and **Rivière.** (Comptes Rendus, 130. pp. 1585–1591, June 11, 1900.)—The authors have pushed to the furthest attainable limits the study of the vapour tension of mercury as the most accessible of metallic vapours. The mercury is contained in two strong coaxial iron tubes communicating with a high-pressure cylinder. When the tubes are heated mercury vapour forms in the lower parts, and its pressure is transmitted by the cylindrical layer of mercury which remains in the portion between the two cylinders. The experiments gave results in good agreement with Regnault's values, but the authors did not succeed in their main object, that of reaching the critical temperature of mercury, owing to the fact that at a red heat mercury is transmitted freely through the substance of the iron. The following are some of the pressures obtained :—

Temperature	400°	500°	600°	700°	800°	850°	880°
Pressure (Atmos.)	2·1	8	22·3	50	102	137·5	162

E. E. F.

1815. *Convection Movements.* **H. Bénard.** (Comptes Rendus, 130. pp. 1004–1007, April 9, and pp. 1065–1068, April 17, 1900.)—A thin layer of liquid heated by a uniform flux of heat from below may assume a stable condition, in which it is broken up into regular polygonal prismatic cellules, in each of which there is an axial ascent and a peripheral descent. The perfection and the permanence of the forms assumed are remarkable. Methods of observation: movement of dust and distribution of it, viewed from above as a transparency; position assumed by reflecting lamellar dust; deposition of dust at the centre of each cellule; travel of floating dust to the periphery of each cellule; optical study of surface depressions (about 1μ for liquid depth 1 mm.) best by treating the cellules as lenses. A. D.

1816. *Thermography.* **R. E. Liesegang.** (Phys. Zeitschr. 1. p. 317, April 14, 1900.)—If equal quantities of hydroquinone and anhydrous sodium carbonate be rubbed together with just sufficient alcohol to wet the powder, a mass is obtained which turns dark blue after a few minutes. If this mixture be painted on a piece of thin note-paper and then rubbed off, it will be found that the blue-coloured paper so obtained is very sensitive to long heat-waves. Thus on exposure for five seconds to the radiation of a gas stove the blue colour is completely bleached. Shadows of coins can be obtained in this way. This sensitive paper is not, however, very durable. F. G. D.

1817. *Kinetic Theory of Gases.* **Z. Győző.** (Ann. d. Physik, 2. 2. pp. 404–413, June, 1900.)—The kinetic theory has been based upon an assumption which can be formulated as follows: That one molecule should at any time have certain velocity components, and that another molecule should have certain other velocity components at the same time, constitutes two phenomena which from the theory of probability are entirely independent of each other. Burbury has endeavoured to free the kinetic theory from this assumption, and has pointed out the necessity of formulating a new theory, since the above assumption cannot continue in time, and conclusions drawn from it lead to contradictions. The author shows that these contradictions are only apparent, and that the formulation of a new theory, however desirable, is not called for by them. The author deals more particularly with the definition of the density and the "streaming velocity" of an aggregation of molecules. E. E. F.

1818. *Thermal Radiation in Absolute Measure.* **J. T. Bottomley** and **J. C. Beattie.** (Phil. Mag. 49. pp. 543–557, June, 1900; Roy. Soc., Proc. 66. pp. 269–282, May 12, 1900.)—Currents of different strengths were passed through two platinum wires in series, which had the same length and diameter but different surfaces (the one being left bright and the other being thinly coated with soot), and which were enclosed in glass tubes with the same vacua. The difference of potential of the ends of a wire, together with the current, gave its resistance, and hence (by a previous determination) its temperature and also its emissive power (C^2R/JS), which was plotted against the temperature. The temperatures ranged from 15° to 743° C. Three pairs of wires were experimented on, of respective diameters 0·0542, 0·025, and 0·015 cm., and for temperatures higher than 200° the average ratios of the emissive power of the wire with sooted surface to that of the bright wire were found to be respectively 5, 4·76, and 4·1. R. E. B.

1819. *Two Theorems of Gibbs'.* **P. Saurel.** (Journ. Phys. Chem. 4. pp. 193–199, March, 1900.)—The equivalence of Gibbs' equation—

$$v_t dp = \eta_t dt + \sum_1^n m_r d\mu_r,$$

for univariant systems with the Clapeyron-Clausius formula, $dp/dt = H/t(v' - v)$, is here demonstrated for the general case of n components, and also the conditional equivalence for bivariant systems. R. E. B.

1820. *Reduction of Problems of Heating by Radiation to that of Heating by Contact. Heating of a Wall of Infinite Thickness.* **J. Boussinesq.** (Comptes Rendus, 130. pp. 1579–1583, June 11, 1900.)—For equilibrium of temperature of two substances in contact we require $u = u_e$, where u is the temperature of one, which may be called the internal, u_e that of the external body. If the exchange of temperature between the internal body and the external space takes place by radiation, we have an equation similar in form, namely, $\phi = u_e$, in which—

$$\phi = u + G\frac{du}{dx} + H\frac{du}{dy} + I\frac{du}{dz},$$

when K denotes the internal conductivity, and G, H, I are $K\cos\alpha$, $K\cos\beta$, $K\cos\gamma$, and $\cos\alpha$, $\cos\beta$, $\cos\gamma$ are direction cosines of the normal.

Internally we have $\frac{du}{dt} = a^2\nabla^2 u$, or $\nabla^2 u = 0$, according as u is constant or not. If the initial temperature at x, y, z is $f(x, y, z)$ or f, we have—

$$\phi = f + G\frac{df}{dx} + H\frac{df}{dy} + I\frac{df}{dz},$$

and for constant temperature $\phi = f$. The function ϕ is determined by equations identical with or analogous to those which determine u in heating or cooling by contact. The author gives examples of the theory worked out mathematically. S. H. B.

1821. *Permanent Changes and Thermodynamics.* **P. Duhem.** (Zeitschr. Phys. Chem. 33. pp. 641–697, June 15, 1900.)—The writer investigates systems depending on two variables, of which one only is affected by hysteresis. In this paper he collects the results of certain of his former memoirs. [See Abstract No. 1228 (1898) and Abstract No. 1354 (1899).] In an introductory chapter he supposes a system defined by three normal variables: (1) the absolute temperature T; (2) the specific volume v; and (3) a variable x which he calls the chemical variable, which, however, according to the form of a certain inequality, is subdivided for the sake of distinction into x variables and ν variables. If f (v, x, T), or shortly f, denote the internal thermodynamic potential, U (v, x, T) the internal energy, S (v, x, T) the entropy, we have the known equation—

$$f = U - TS.$$

And if π denote external pressure, the conditions for equilibrium are—

$$\frac{df}{dv} + \pi = 0$$

$$\frac{df}{dx} = 0$$

The conditions for stability are deduced from these. The author then for-

mulates three laws : (1) The law of variation of the position of equilibrium at constant temperature, viz., "Every increase of pressure taking place reversibly and at constant temperature changes the position of equilibrium in such a way that the specific volume diminishes." (2) The law of variation of the position of equilibrium with change of pressure. This gives rise to two cases according as $\frac{d^2f}{dvdx} > \text{or} < 0$. In the second case the chemical variable x is distinguished as a y variable. (3) The law of variation of the position of equilibrium with change of temperature. The condition of the thermodynamic potential under constant pressure is also discussed.

In the first chapter is treated the case in which the variable v alone is affected by hysteresis.

In the second chapter the variable x (*i.e.*, x or y) alone is affected by hysteresis, and in paragraph (1) the foundation of the theory is explained on this hypothesis ; and in (2) the x and y variables are distinguished. In paragraph (3) the author treats of isothermal variations, with two assumptions, namely—(*a*) For given T and x, v diminishes as π increases ; (*b*) every isothermal variation is subject to the law (2) of the introduction. Paragraph (4) deals with isobaric variations. The author assumes, thirdly, that every isobaric variation is subject to law (3) of the introduction. Next in paragraph (5) are discussed closed cycles and "natural states," and the distinction is drawn between systems of the first or second kind according as for a certain function ϕ, $\frac{d\phi(x,\pi,T)}{dx} > \text{or} < 0$.

The writer then, in paragraph (6), defines pseudo-reversible processes as those in which throughout a cycle of changes the system is always in a natural state, but at the end π and T return to their initial values. He makes with respect to these a fourth assumption, viz., every pseudo-reversible process fulfils Clausius' equation, $\int \frac{dQ}{T} = 0$. In paragraph (7) is discussed Clausius' inequation (*Ungleichung*), and we have a fifth assumption, viz. : In every possible irreversible process Clausius' inequation, $\int \frac{dQ}{T} > 0$, is satisfied.

In the application of the theorems to isothermal variations, paragraph (8), a sixth assumption is made, viz. : The neighbourhood of a natural state is for a system of the first kind when for a certain function Ω (the apparent thermodynamic potential under constant pressure π)—

$$\frac{d^2\Omega}{dv^2} > 0$$

for a system of the second kind when—

$$\frac{d^2\Omega}{d\lambda^2} < 0$$

He then in paragraph (9) discusses the law of the variation of the natural state by pressure ; in (10) by change of temperature ; in (11) the conditions for the fulfilment of Clausius' inequation throughout an isothermal process ; and (12) throughout an isobaric process. Paragraph 13 deals with the position of a simple cycle with respect to the series of natural states, and paragraph (14) with isobaric variations. S. H. B.

SOUND.

1822. *Pitch of Galton's Whistles.* **M. T. Edelmann.** (Ann. d. Physik, 2. 3. pp. 469–482, July, 1900.)—The author gives a new form of Galton's whistle, in which the blast from a ring-shaped mouthpiece impinges upon the sharp edge of the pipe, which is also circular, and can be brought to within any desired small distance from the mouthpiece. This whistle gives very strong notes, whose pitches are studied by means of Kundt's dust figures. It is found that the highest limit of hearing is a little beyond 50,000 complete vibrations per second. By making the diameter of the pipe as small as 2 mm., the author has succeeded in constructing pipes giving the very high pitch of 170,000 vibrations per second. E. E. F.

1823. *Perception of Pure Notes.* **W. Heinrich.** (Acad. Sci. Cracovie, Bull. pp. 37–45, Jan., 1900.)—The author quotes a number of experiments which show that in a pure note which is just perceptible to the ear no variations of intensity are heard, even though the note should itself vary in intensity at the source. This is all the more remarkable as such variations of intensity can be expected to result from the pulsation of the blood-vessels and the corresponding variation of the tension on the ear-drum [see following Abstract]. When the sound heard is not a pure note, but a slight noise, such as the ticking of a watch, the ear is able to perceive the difference of intensity. The author does not hazard an explanation. E. E. F.

1824. *Function of the Ear Drum.* **W. Heinrich.** (Acad. Sci. Cracovie, Bull. pp. 105–111, March, 1900.)—To every tension of the ear-drum there belongs a single note to which it responds. Any note of a different pitch produces no effect. This is made evident by distending the ear-drum in an interference apparatus, when the fringes only disappear on sounding the proper note. The note may be changed by changing the tension of the membrane. The author regards the ear-drum as an organ capable of accommodation. It does not respond to irregular noises, and the mechanism of their transmission is not yet explained. E. E. F.

1825. *Sensitive Flames and Difference Tones.* **N. Schmidt.** (Deutsch. Phys. Gesell., Verh. 2. 2. pp. 22–23, 1900.)—A glass tube drawn out at the end to about 1–1·5 mm. diameter, and supplied with gas at a pressure of about 15 cm. of water, gives a flame at the nozzle about 40–60 cm. long which is very sensitive to noises or tones of a certain pitch.

If two Galton whistles are sounded in the neighbourhood the flame acts just as it would for one so long as the whistles agree in pitch, but when the pitch of one is altered the flame begins to *resound* to the "difference tone." This is at first evident to the eye, and as the difference increases the vibrations are seen to become quicker and quicker until they become audible to the ear as a low note, and they can then be followed by the ear quite distinctly until their frequency reaches two to three thousand. J. B. H.

1826. *Transverse Vibrations of India-Rubber.* **T. J. Baker.** (Phil. Mag. 49. pp. 347–351, April, 1900.)—The pitch of the note produced by twanging

an indiarubber band which is stretched over the fingers is influenced but little by the tension, particularly if this is considerable. Measurements of the pitch of the note produced under various tensions, as well as the variations of length and sectional area, show that in indiarubber Young's modulus is proportional to the square of the stretched length of the cord. That being so, the author proves theoretically that the frequency of a greatly stretched indiarubber cord will increase very slowly with the increase of tension. The formula deduced for the relation between the pitch n, the natural length l, and the stretched length L is—

$$n \propto \sqrt{\frac{L-l}{L}},$$

which gives a very slow increase of n with L when the latter is large.

E. E. F.

1827. *Vibration of a String under a Moving Force.* **M. Radaković.** (Akad. Wiss. Wien, S.ber. 108. pp. 577-612, 1899.)—In the motion of a train over a bridge, the latter is subjected to two kinds of forces whose point of application is displaced. One of them is the moving weight of the train, the other is the succession of impulses produced by the rotation of the main wheels of the engine and the crossing of rail joints. The full theoretical discussion of these impulses has never been carried out, though Stokes, Willis, Boussinesq, and Steiner have treated certain restricted problems in connection with it. The author, therefore, attempts the mathematical discussion of a simplified problem, that of the vibration of a string excited by a series of impulses, and carries it out completely. In doing so, he uses in the first instance d'Alembert's integral, but also employs that of Bernouilli, which indicates a method of solution capable of being applied to other vibrating systems, notably to a rod vibrating transversely.

E. E. F.

REFERENCES.

1828. *Tuning-forks.* **A.** and **V. Guillet.** (Comptes Rendus, 130. pp. 1002-1004, April 9, 1900.)—Method of keeping up the vibrations of a tuning-fork by connecting it with a microphone and adjusting. A. D.

1829. *Problems in Acoustics.* **C. K. Wead.** (Science, 11. pp. 732-735, May 11, 1900. Paper read before the Washington Philosophical Society.)—A brief report from the Committee on Physical Science on the present state of acoustics.

ELECTRICITY.

THEORY AND ELECTROSTATICS.

1830. *Distribution of a Gas in an Electric Field.* **G. W. Walker.** (Phil. Mag. 49. pp. 529–538, June, 1900. Paper read before the Physical Society of London.)—The author supposes a gas consisting of diatomic molecules and also of dissociated atoms. Of the two atoms forming a molecule, one has a positive charge e of electricity, the other the corresponding charge $-e$. The free atoms are supposed to retain the same charges e and $-e$. The positive and negative atoms are not assumed to be equal in number per unit of volume.

The author investigates the mathematical properties of a medium so constituted, with reference to pressure, density and electric force, or current. He supposes that the recombination of positive and negative atoms to form a molecule gives rise to luminosity. If the regions of maximum density of matter coincide with those of least electric density, that is where the numbers of atoms of the two classes are equal; it is here that we should expect the greatest luminosity. This state of things is closely related to the phenomena of a striated vacuum tube. It is discussed in that relation and with reference to a result obtained by Goldstein (Wied. Annalen, xv. p. 277, 1883), and some experiments of R. S. Willoughs, at the Cavendish Laboratory. S. H. B.

1831. *Poynting's Hypothesis.* **P. S. Wedell-Wedellsborg.** (Zeitschr. Phys. Chem. 33. pp. 631–635, June 1, 1900.)—The author criticises Poynting's hypothesis which assumes that the electric tubes of force move at right angles to themselves into a conductor carrying a current, and are then converted into heat. He claims that this hypothesis contradicts the conservation of energy and the proportionality between potential and electric density at constant current. He points out that if it were true, a current gradually increasing in a solenoid would increase its own intensity without limit.

E. E. F.

1832. *Conservation of Electricity.* **O. M. Corbino.** (N. Cimento, 11. pp. 136–140, Feb., 1900.)—Lippmann showed (Ann. de Chimie et de Phys. 5 ser. t. 24, p. 159, 1881) the importance of the principle of conservation of electricity. The author here criticises Lippmann's formulæ on the ground that certain functions are considered as exact differentials when they are not necessarily so. Sacerdote's formulæ, as far as they go, are not open to this objection. A. D.

1833. *Ionic Theory of Metals.* **P. Drude.** (Phys. Zeitschr. 1. pp. 161–165, Jan. 6, 1900.)—Electric conduction in metals may be considered as due to the transportation of ions, and this view leads to a simple explanation of the optical characters of metals which is free from contradictions and complicated assumptions. Since there is no visible transportation of masses, it may be assumed, with Giese, that the metallic ions convey the current only through very short distances, after which they pass on their charges to neighbouring ions. Leaving this process of transfer out of account, and supposing all ions

capable of conveying electricity to have an equal mass, the current in a metal subjected to a constant electric force may be regarded as due to the wandering of ions of constant mass and constant charge with a certain constant average velocity. Let the number of these ions per unit of volume be N. There must be several kinds of ions, two at least, for there is no free charge, and we have, therefore,

$$\Sigma Ne = 0 \qquad (1)$$

when e is the elementary charge.

Regarding for the present only one kind of ions, and denoting by ξ, η, ζ the components of the displacement of an ion from its position of rest, we have in case of a constant electric force X

$$\frac{\partial \xi}{\partial t} = veX \qquad (2)$$

This equation can be interpreted as meaning that under the influence of a friction proportional to $\frac{\partial \xi}{\partial t}$ the ion acquires a constant velocity under a constant force X. If X changes, the equation of motion of the ion becomes

$$m \frac{\partial^2 \xi}{\partial t^2} = eX - \frac{1}{v} \frac{\partial \xi}{\partial t} \qquad (3)$$

The quantity $\frac{1}{v}$ may be called the friction of the ion, and v its mobility; v is really the velocity which the ion assumes under the permanent influence of one dyne.

If we introduce the additional assumption that the ion is driven back to its position of equilibrium by a force proportional to ξ, the equation of motion would be

$$m \frac{\partial^2 \xi}{\partial t^2} = eX - \frac{1}{v} \frac{\partial \xi}{\partial t} - p\xi \qquad (4)$$

This would have to be done in order to explain the optical properties of insulators. In that case the displacement ξ is finite. If in the course of this displacement the ion does not meet another to which it can communicate its charge, a constant force X cannot produce a constant current. Hence ions subject to equation (4) may be called insulating ions, and those subject to equation (3) conducting ions. Equation (3) can, however, only be regarded as applying to an average state, for strictly speaking all ions will be subjected to restoring forces, and the velocity of the conducting ions will be disturbed by impact upon the neighbouring ones.

The x component, j_x of the current density brought about by the displacement ξ has the value

$$j_x = eN \frac{\partial \xi}{\partial t} \qquad (5)$$

all measurement being made in electrostatic units. The total current is obtained by adding to the ionic currents the displacement current in the ether, which has the value

$$j_x = \frac{1}{4\pi} \frac{\partial X}{\partial t}$$

and it may then be assumed that the difference in the electrical behaviour of different bodies is solely due to differences in the qualities of the ions, but that the ions are immersed in an ether having everywhere the same properties.

The total current density in the direction OX is then

$$j_x = \frac{1}{4\pi}\frac{\partial X}{\partial t} + \Sigma e N \frac{\partial \xi}{\partial t} \qquad (8)$$

If X is constant, and $\frac{\partial \xi}{\partial t}$ is zero for zero time, we have

$$\frac{\partial \xi}{\partial t} = ve X (1 - e^{-t/mv}) \qquad (9)$$

and if we put

$$mv = \theta/2\pi \qquad (10)$$

θ is the time during which a constant electric force X must operate before an ion of mass m assumes a velocity only differing from its final velocity by the $e^{2\pi}$th part, say 0·2 per cent. This time θ may be called the excitation period (*Anregungszeit*) of the ion.

For $t = \text{inf.}$, we have from (9) and (8)

$$j_x = \Sigma e^2 v N \,.\, X = \sigma' X \qquad (11)$$

where the constant

$$\sigma' = \Sigma e^2 v N \qquad (12)$$

and has obviously the meaning of the "conductivity" of the body in absolute electrostatic units.

If X and ξ are periodically variable, they must be put as proportional to $e^{i \cdot 2\pi t/\tau}$, where $i = \sqrt{-1}$ and τ is the period. Then we have by (3) and (10) for the conducting ions

$$e\frac{\partial \xi}{\partial t} = -i\,\frac{\tau}{2\pi}\,\frac{e^2 v}{1 + i\theta/\tau}\cdot\frac{\partial X}{\partial t} \qquad (14)$$

Supposing only conducting ions to be present, we have, by (8) and (14)

$$4\pi j_x = \frac{\partial X}{\partial t}\left\{1 - 2i\tau\Sigma\,\frac{\sigma}{1 + i\theta/\tau}\right\} \qquad (15)$$

and on putting

$$4\pi j_x = \varepsilon\,\frac{\partial X}{\partial t} \qquad (16)$$

where ε can be a real or complex quantity depending upon τ, we have by Maxwell's theory the following equation for the refractive index n and the absorption κ of the body :—

$$n^2(1 - i\kappa)^2 = \varepsilon \qquad (17)$$

From a combination of these equations, the author draws the following conclusions, which he verifies for 18 metals :—

(1) κ may be greater than unity. (2) When κ is < 1, then $n^2(1 - \kappa)$ must also be < 1. (3) $n^2\kappa$ is always $< \tau\Sigma\sigma$, *i.e.*, $n^2\kappa < \tau\sigma'$. (4) The more $n^2\kappa$ lies below $\tau\sigma'$ in a given metal, the greater must be the excitation period θ as compared with τ in the case of some kinds of ions whose conductivity σ is a perceptible portion of the total conductivity σ', and the greater is κ in comparison with n. (5) $n\kappa$, $n^2\kappa$, and $n^2(\kappa^2 - 1)$ must always increase with τ. (6) Generally speaking, n increases with τ. But in metals with small n and large κ, n may decrease with τ.

The author then proceeds to determine the characteristic constants σ and θ, of the various kinds of ions from the existing records of n and $n\kappa$ and the

reflective power as lately investigated by Hagen and Rubens. In the case of the two nickel ions, the following values are obtained :—

$$\tau\sigma' = 6{\cdot}0 \qquad \tau\sigma^2 = 53$$
$$\theta_1/\tau = 0{\cdot}192 \qquad \theta_2/\tau = 16{\cdot}0$$

for yellow light.

Hence the masses of the two ions are in the ratio of 9·45 : 1, and it is most likely that the larger mass belongs to the positive ions. The latter also have the longer excitation period, but their final velocity is greater, and nearly proportional to their mass. For 1 volt per cm. the negative ions would move at a rate of 0·11 cm. per second, and the positive ions at the rate of 0·96 cm. per second, or about 200 times the rate of travel of the ions in electrolytes. The amplitude of their motion remains, however, well below the radius of molecular action, being 17×10^{-17} cm. in the negative nickel ions and $0{\cdot}6 \times 10^{-17}$ in the positive ions. The total mass of positive and negative ions contained in 1 c.c. of nickel comes out as 1·7 mg., or about 1/5,000th of the total mass. In silver, platinum, and steel it is sufficient to assume the presence of conducting ions only, while the high reflective power of gold and copper point to the conclusion that insulating ions are present as well, and that their proper oscillations lie in the infra-red region. It is also possible that some metals, such as nickel, contain other ions of much greater mass, which are optically ineffective, but considerably influence Hertzian waves. E. E. F.

1834. *Weight of Electron.* **R. v. Lieben.** (Phys. Zeitschr. 1. pp. 237–238, Feb. 24, 1900.)—The author deduces the weight of "electron" from the minute change in weight observed by Landolt (Zeit. Phys. Chem. 12. 1, 1893) in certain chemical reactions. In the reaction

$$HIO_3 + 5H_2SO_4 + 5KI = 6I + 5KHSO_4 + 3H_2O$$

the mean loss in weight was 0·077 mg. per molecule, a value which is similar to that deduced by Kaufmann from observations on kathode rays, viz., 0·58 mg. Other examples are also quoted. T. M. L.

1835. *Atmospheric Electricity.* **M. Brillouin.** (Journ. de Physique, 9. pp. 91–94, Feb., 1900.)—Cold, dry ice is very sensitive to the negative-electricity-discharging effect of ultra-violet rays, about one-tenth as much so as zinc; water is not at all so. Dry crystals of ice floating in an electric field would become charged positively and negatively, but the negative charges would escape under the influence of sunlight. The air remains an insulator, and the surrounding air becomes negatively charged. When the cirrus moves away from this air, it bears a positive charge; and if it evaporates, the air now surrounding it becomes positively charged. When the negatively charged air descends, it charges the earth negatively. At sea the negatively charged air, on expansion, forms negatively charged cumuli. At the sea-level, ultra-violet radiations have mostly been absorbed, and water is not sensible to their action; so that their direct effect is not perceptible. The effects of the travel of masses of air explain many of the phenomena of storms; and the blending of the positive and negative charges by night, when there has been no such travel, accounts for auroras, luminous clouds, and diffused illumination of the sky on summer nights in our latitudes. Variations in sun-spots cause variations in the ultra-violet radiations from the sun. The initial electrostatic field required to start the action described is produced during the displacements of the higher regions of the atmosphere with reference to the magnetised terrestrial globe. [See also Abstract No. 188 (1898).] A. D.

1836. *Lightning and Atmospheric Electricity.* **A. G. McAdie.** (U.S Weather Bureau, Bull. 26. pp. 9–44, 1899.)—This paper deals briefly, in a popular manner, with kite experiments and thunderstorm observations at Blue Hill Observatory, on Washington Monument, at San Francisco, &c., and reviews the different hypotheses on atmospheric electricity, with special regard to the views of O. Lodge on lightning and lightning conductors and protection. A few pages are devoted to auroræ. Among the illustrations are some of the author's photographs of lightning flashes. H. B.

1837. *Energy Absorbed by Condenser.* **H. Pellat** and **F. Beaulard.** (Comptes Rendus, 130. pp. 1457–1460, May 28, 1900.)—The case dealt with is that in which a condenser is subjected to a sinusoidal difference of potential. The treatment is based upon the proved existence of a real polarisation, and upon the assumption that the rate of polarisation is for any given substance solely a function of the difference J—j between the actual polarisation j and the limiting polarisation J.

Let the armatures of surface s be separated by a single dielectric of uniform thickness c and of true specific inductive capacity k; at a time t, let v be the difference of potential of the armatures and j the real polarisation; let dm be the variation of the charge of the armatures during the time dt, and therefore the electric energy furnished during this time to the condenser be $dw = \mathrm{V}dm$. Then, according to the author's former work,

$$m = \mathrm{S}\sigma = \frac{\mathrm{KSV}}{4\pi c} + \mathrm{S}j$$

$$dm = \frac{\mathrm{KS}}{4\pi c}d\mathrm{V} + \mathrm{S}dj$$

and

$$dw = \frac{\mathrm{KS}}{4\pi c}\mathrm{V}d\mathrm{V} + \mathrm{SV}dj$$

If V is periodically variable, the energy w_1 absorbed per unit of volume during one period becomes

$$w_1 = \frac{w}{\mathrm{S}c} = -\int_0^T j d\phi$$

where ϕ is the energy of the electric field.

The final equation arrived at is

$$w_1 = \frac{2\pi^2 bh\mathrm{V}_0^2 n}{c^2(4\pi^2 n^2 + b^2)}$$

where n is the frequency, b is defined by the equation $\frac{dj}{dt} = b(\mathrm{J}-j)$, and h by the equation $\mathrm{J} = h\Phi$, J being the final real polarisation for the final field Φ when the difference of potential of the armatures is kept constant.

As b is a fraction of unity for good dielectrics, while $r\kappa n$ usually is more than 100, b^2 is quite negligible in comparison with $4\kappa^2 n^2$, and the above formula becomes practically

$$w_1 = \frac{bh\mathrm{V}_0^2}{2c^2 n}$$

This may be further simplified by putting W_1 for the energy absorbed per unit volume and unit time, when we get

$$\mathrm{W}_1 = bh\phi_0^2,$$

ϕ_0 being the effective intensity of the field. The best condenser dielectrics

for industrial purposes are therefore those for which b and h are small. With very strong fields, the energy given by the above equation is too high, and a smaller exponent would have to be substituted for 2. But this is due to the fact that h diminishes the fields of great intensity. E. E. F.

DISCHARGE AND OSCILLATIONS.

1838. *Oscillatory Discharge of Air Condenser and Determination of "v."* **O. J. Lodge** and **R. T. Glazebrook.** (Cambridge Phil. Soc., Trans. 18. pp. 136–196, April, 1900.)—The elaborate research here detailed consists essentially of the following three absolute determinations: (1) The capacity of a standard condenser which is K times a length; (2) The self-induction of a coil which is μ times a length; (3) The period of one oscillation of the electrical discharge of this condenser through the coil just named, under circumstances where the damping influences are not appreciably disturbing.

Many minor matters are discussed and corrections made where necessary, but the above three are the main quantities concerned, and are connected by the relation—

$$T = 2\pi\sqrt{\mu l.\, Kl_2},$$

and this formula would be verified if the resulting value for the product of the as yet entirely unknown constants, μ and K, agreed at all closely with the already otherwise determined value, viz., the square of the reciprocal of the velocity of light. The research was undertaken with a view to affording another useful redetermination of "v," but on a closer examination of the experimental conditions, and of the departures from the above simple theory thus involved, the authors prefer to regard the work as a study of the oscillatory discharge which incidentally leads to a determination of "v" by a novel method.

After many preliminary trials the form of air-condenser finally adopted consisted of eleven flat plate-glass slabs entirely covered with tinfoil so as to resemble slabs of metal. They were each nearly 60 cm. square, and were kept about 5 mm. apart by five pieces of ebonite placed like the pips on a card. In estimating the capacity of this condenser corrections were made for the edges, for the thickness of the plates, and for the sharpness of the edges also, for the ebonite separators, and for the proximity of the floor, walls, and roof. The condenser capacity is thus found to be 5,803 cm.

The coil adopted consisted of 4,330 yards of No. 22 tinned copper wire covered with two coats of pure indiarubber and arranged in two parallel coils, each of internal diameter $10\frac{3}{4}$ inches, 4 inches deep, and 2 inches wide. These coils were arranged so that they could be used in series, in parallel, or used separately. In practice they were usually joined in simple series. The self-induction of the whole coil was determined by Maxwell's method, with great care, and found to be—

$4{\cdot}6362$ "International Quadrants,"
or $4{\cdot}6362 \times 10^9\mu_0$ centimetres.

The determination of the period was made as follows: A photographic plate was whirled by a turbine at from 64 to 85 revolutions per second, and upon this plate the image, about natural size, of the spark was focused. For controlling and determining the speed of rotation a stroboscopic disc and electromagnetically-maintained Kœnig fork were used, the fork's period being known by a mechanical counter and a chronometer compared each day

with a standard clock rated from the observatory. The photographic negative was subjected to careful micrometric examination on a circular graduated plate. For one such plate the wave-length occupied an angle of 26° 11′, which corresponded to a frequency of 880 per second. The simple theory is then corrected for the electrostatic capacity of the coil, and it is found that from the above data "v" would have the value $3{\cdot}009 \times 10^{10}$ cm. per second. E. H. B.

1839. *Resistance of Sparks.* **P. Cardani.** (N. Cimento, 11. pp. 113–133, Feb., 1900; Como Congress, September 22, 1899.)—As the resistance of the circuit increases, the resistance of sparks increases. For every explosive distance the apparent resistance of the spark first rises and then falls with progressive diminution of the pressure, these variations being small for small, and greater for greater explosive distances. The maximum resistance of the spark is reached at a pressure which is lower the greater the explosive distance; and at 0·01 cm. mercury pressure, the resistance of the spark is sensibly the same for all explosive distances. A. D.

1840. *Spark at Break between Metals.* **L. Kallir.** (Ann. d. Physik, 2. 2. pp. 250–265, June, 1900.)—In an alternate-current circuit, the spark at break is characterised by a very rapid disappearance. This fact is of practical importance, inasmuch as it ensures that no metallic arcs play between the terminals of an alternate-current switchboard. This is connected with the fact that it has hitherto been found impossible to get an alternate-current arc to play between metallic terminals. The duration and intensity of the spark in question depends upon various circumstances, such as the shape of the terminals in contact, the evaporation of the material forming the spark, the speed with which the terminals are separated, and the phase of the period at which the interruption takes place. To study the effect of these elements, the author projects the spark upon a revolving sensitive plate. He employs as terminals a platinum or copper point dipping into mercury, and finds that the uncertainties connected with the elements mentioned preclude the quantitative control and prediction of the spark phenomena. But it is certain that under ordinary pressures the spark has a duration not exceeding a semi-period. Under peculiarly favourable circumstances it assumes the character of an intermittent continuous-current spark covering several half-periods. In a vacuum, on the other hand, sparking takes place in both halves of the period. This may possibly be due to the scarcity of oxygen. It appears to be immaterial whether the resistance in the circuit is inductive or non-inductive. E. E. F.

1841. *Point Discharges.* III. **E. Warburg.** (Ann. d. Physik, 2. 2. pp. 295–316, June, 1900.)—This part of the author's investigation [see further Abstracts Nos. 275 and 453 (1899)] deals with the case where the point is kept at a constant potential face to face with a plate put to earth, and the luminosity is confined to the immediate neighbourhood of the point. In this case it may be assumed that the formation of ions is confined to one sign only, which is the same as the sign of the charge imparted to the point. The arrangement should therefore be particularly effective in bringing out the differences in the properties of the two classes of ions. To determine the fall of potential away from the point, the author used a platinum probe consisting of a wire fused into a glass tube. This gave somewhat smaller values than Kelvin's water-dropping electrometer, but the differences were not great. It was

found that the fall of potential between the point and the probe, distant 0·75 mm. from it, was smaller with a negatively electrified point than with a positive point. In air the ratio was about 4 : 3 ; in hydrogen it was greater, in oxygen much less. Since in the glow discharge the fall of potential at the kathode is greater than that at the anode, it appeared interesting to study the transition from the point discharge to the glow discharge. It was found that during that transition the potential gradient underwent no marked change in the case of a negatively charged point, but that it fell to one-thirteenth of its former value in the case of a positively charged point. This indicates that the electric process changes during the transition in the latter case, but not in the former. The author supposes that in the case of a negative point the density of ions increases considerably when the glow discharge sets in, as indicated by the narrow luminous strip issuing from the point. The increased ionic density brings about an increased conductivity, and therefore also a decreased potential gradient. The author points out the remarkable influence of small impurities upon the difference of current strength, as mentioned in Abstract No. 120 (1900). E. E. F.

1842. *Influence of Incandescent Bodies on Gaseous Phosphorescence.* **K. v. Wesendonck.** (Ann. d. Physik, 2. 2. pp. 421–423, June, 1900.)—In connection with Stark's paper on this subject [see Abstract No. 642 (1900)] the author remarks that most of the effects observed could be produced with an induction coil instead of a high-potential battery, and were actually observed and described by him in 1885. The current at make does not seriously interfere if the glowing body is introduced through the side of the tube and is not connected to earth, in which case it would act as an electrode. Such a disturbing current would be indicated by the stratification of spaces otherwise dark. E. E. F.

1843. *Heat due to Kathode Rays.* **P. Villard.** (Comptes Rendus, 130. pp. 1614–1616, June 11, 1900.)—At the point where the kathode emits kathode rays a considerable amount of heat is disengaged, owing to the impact of the matter which goes to form the canal rays [see Abstract No. 1048 (1898)]. The heating of the kathode is, however, not confined to high exhaustions. The filament of a lamp can be made incandescent by means of an induction coil, if it is made into a kathode, and another filament is mounted as an anode in the same tube. The phenomenon may be produced at pressures up to one atmosphere by using metallic instead of carbon filaments. Care must be taken to have the current impulses in one direction only, and not to have the period of interruption the same as the period of elastic vibration of the filament. The difference of potential required to produce incandescence by the kathode effect is much higher than that required by the Joule effect, but the current required is much less. Tesla's incandescence phenomena are probably due to kathode heat. E. E. F.

1844. *Kathode Rays and Deviable Radium Rays.* **P. Villard.** (Comptes Rendus, 130. pp. 1010–1012, April 9, 1900.)—When kathode rays strike insulated metal there is both diffuse reflexion and an emission of kathode rays normal to the pseudo-reflecting surface. If the metal struck be very thin, there is a pseudo-refraction of kathode rays emitted by the obverse side normal to the surface. The deviable rays from radium act as kathode rays do, but the pseudo-refracted rays are accompanied by rays directly transmitted through the metal and due to the non-deviable radiations from the radium. A. D.

1845. *Production of Kathode Rays by Ultra-violet Light.* **P. Lenard.** (Ann. d. Physik, 2. 2. pp. 359–375, June, 1900; Akad. Wiss. Wien, S.ber., Oct., 1899.)—The author has made the important discovery that the impact of ultra-violet light upon a negatively charged conductor causes the latter to give out rays having all the characteristics of kathode rays. A wide vacuum tube is provided with a side tube closed by a quartz plate and a tinfoil screen, through an opening in which ultra-violet light is admitted into the tube from a zinc spark gap. The ultra-violet light impinges slantingly upon an electrode connected with an electrometer, and another electrode with a central aperture is mounted in the tube so as to face the first one. By continued heating and the working of a large induction coil the tube is brought into such a condition of evacuation that it no longer allows the discharge to pass, and the latter goes over the surface of the tube. If then the electrode is charged negatively and connected with an electroscope, the leaves of the latter collapse rapidly when the electrode is struck by ultra-violet light, and the divergence also diminishes rapidly when a condenser is inserted. Positive charges, on the other hand, remain, or decrease exceedingly slowly. With the quadrant electrometer it can be shown that the uncharged electrode assumes under the influence of the light a positive charge which can mount up to a potential of 2·1 volts. All these phenomena are annulled by placing a thin plate of mica in the path of the rays.

Measurements made by means of a large resistance show that the quantity of electricity discharged in the unit of time is practically independent of the potential of the electrode. This applies to potentials ranging from —45,000 volts to —100 volts. With smaller values the discharge is less rapid. But this is probably due to the intermittence of the source of light employed, which allows some ions to return to the electrode.

Experiments at various pressures show that the constancy of the discharge is only found in the "absolute" vacuum. Even at 0·002 mm. Hg pressure, the quantity of electricity discharged increases with the difference of potential.

The rays are propagated in straight lines, as may be shown by mounting behind the perforated electrode various auxiliary electrodes. Only those in the direct line of the radiations show a charge, and always a negative one. By means of a magnetic field the rays can be deflected so as to impinge upon the lateral electrodes. Quantitative measurements gave values for the ratio e/m of charge to mass of a particle, and of v the velocity of propagation. The ratio e/m came out as $11{\cdot}5 \times 10^6$, and v came out as $0{\cdot}12 \times 10^{10}$ cm. per second for a potential of $607{\cdot}10^8$ c.g.s. magnetic units, and 0·54 cm. per second for a potential of 12,600 units. The former speed is only one-thirtieth of the velocity of light, and these rays are therefore the slowest yet discovered. This explains why they produce no phosphorescence on the wall of the tube.

The above reasoning applies to rays in the highest vacuum attainable. It shows that the kathode rays can now be obtained without the presence of a gas and at any negative potential. When a gas is present it absorbs the kathode rays and propagates the charge by slow convection. At the same time it is rendered conducting. This explains why larger quantities of electricity are discharged in a low than in a high vacuum. It also explains the action of ultra-violet light in lowering the spark potential between metals in air when it impinges upon the negative electrode. E. E. F.

1846. *Hertz Resonators.* **A. Turpain.** (Comptes Rendus, 130. pp. 1541–1544, June 5, 1900.)—The author considers the case in which the circular wire resonators, as used by Hertz, have their plane normal to the direction of the

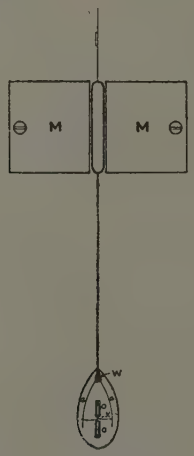
wires which concentrate the field. A resonator kept in this position shows a maximum spark-length in the micrometer gap when the ray passing through the gap is normal to the plane of the two stretched wires, and a minimum when the ray is in the plane of the wires. When the resonator contains four spark gaps on its circumference the spark gaps in the former position are active, and in the latter position inactive. This gives two nodes and two ventral segments for each resonator, a fact which is opposed to the rule that, apart from the disturbance of the gap, the length of the resonator is equal to half the wave-length of the ray which excites it. The author has therefore further examined this case by enclosing the resonator in an exhausting circular glass tube of the same size and noting the luminous phenomena attending excitation. If it is admitted that the most intense luminosity appears at the points where the variation of electric density is greatest, the aspect of the resonator agrees with a distribution such that there is a node at each extremity and a ventral segment at a point equidistant from both. E. E. F.

1847. *Absorption of Electric Waves.* **J. A. Fleming.** (Electrician, 45. p. 222, June 1, 1900.)—The author gives some preliminary results concerning the absorption of electric waves, obtained with an apparatus which produces and detects waves only a few inches in length, to be described shortly. He finds that paraffin oil, benzol, turpentine, and all insulating liquids of low dielectric constant are exceedingly transparent, but water and many liquids of high dielectric constant are very absorptive. The waves employed (about 8-inch wave-length) pass easily through a wood board an inch thick, a dozen sheets of window glass, a dozen thicknesses of dry washleather, a thick slab of ebonite, but are stopped almost completely by a couple of wet cloths, or ½-inch thickness of water, and by any substance which is very moist. Ice, on the other hand, if *dry* on the surface, is transparent to them. Constructing a large ice prism, the author has readily refracted these rays by it, and measured approximately the refractive index of ice for them. It proves to be a number near to 1·7 or 1·8. The human hand and body are very opaque to these particular electric rays, and so are some vapours. The red nitrous fumes produced by the action of nitric acid on copper appear to absorb them to some extent even if only a few inches in depth, although they will pass easily through a slab of ice some four inches in thickness. They are easily reflected from a surface of glass, and a very striking experiment may be shown by reflecting them at 45° from the palm of the hand. By splitting an electric beam into two parts and sending the two portions along two zinc tubes, which can be varied in length, the interference of two electric rays is most easily shown and the wave-length measured. Any substance which has conductivity or large dielectric constant in one direction only is very absorptive of these rays when that direction is placed parallel to the electric force of the ray falling upon it. Thus a paper of pins stops the rays when the pins are held with their length parallel to the direction of the electric force, but not when they are held normal to it. The strongly absorptive character of distilled water or alcohol shows that in these cases it is not so much conductivity as large dielectric constant which seems a determining factor. As the experiments have not proceeded very far, it is necessary to refrain from generalisation, but it appears very much as if all substances which contain in their chemical molecule either hydroxyl (HO) or nitryl (NO_2) are in the liquid, and perhaps in the gaseous, form very opaque to electric radiation, the wave-length of which is not more than a few inches. In the case of water it would seem that the absorption band known to exist in the ultra-red water

spectrum extends as far as wave-lengths 200,000 or 300,000 times as long. The electric refractive index for ice is in very fair agreement with the square root of the dielectric constant for high frequency reversals of electric force.

E. E. F.

1848. *Radio-Micrometer for Electric Waves.* **G. W. Pierce.** (Amer. Journ. Sci. 9. pp. 252–260, April, 1900.)—Klemenčič first made use of the thermo-junction for the measurement of electric waves. His device consisted of two thin sheets of brass, having soldered to them a very fine platinum and a very fine platinum-nickel wire respectively, which were crossed in the middle between the two strips, and thence conveyed off at right angles and soldered at their other ends to the leads of a very sensitive galvanometer. This resonating system was fixed at the focal line of a cylindrical reflector. Electric oscillations between the two strips produced heating at the knot, which gave rise to a current through the galvanometer. The author has combined this principle with that of Boys' radio-micrometer. The arrangement is shown in the diagram, where MM are the poles of a horseshoe



magnet. The coil consists of a single loop of silk-covered copper wire. The resonating system consists of two copper cylinders, *o o*, 8 mm. long and 1 mm. apart, which have a thin constantan and a manganin wire soldered to their ends. The resonators are sewn on to a mica vane, and the springiness of the copper leads *a a* keeps the thermo-junction in contact. To protect the latter from radiant heat, the apparatus is cased in wood.

The suspension is hung by a fine quartz fibre, of which the force of torsion serves as control. The weight of the system is 0·27 gram., of which the mirror weighs 0·05, and the resonating cylinders 0·144 gram. The period of a swing one way is three seconds. The resistance of the thermo-junction is about two ohms.

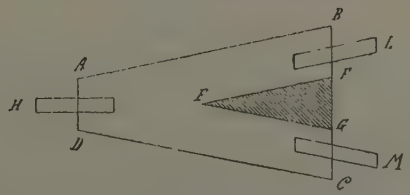
It might be supposed that the sensitiveness of the instrument could be increased by making the coil of about thirty turns, which would give it a resistance equal to that of the thermo-junction. It is found, however, that the control by the field, due to the magnetic properties of the copper, is so great

as to give a smaller sensitiveness with a large number of turns than with a single loop. This instrument, because of the resistance of the thermo-junction, cannot be made to have the extreme delicacy of Boys's original radio-micrometer. It has, on the other hand, a sensitiveness that is not easily obtainable by the use of a thermo-junction with a low resistance galvanometer. E. E. F.

1849. *Effect of Feelers attached to a Righi Oscillator.* **A. Lindemann.** (Ann. d. Physik, 2. 2. pp. 376–397, June, 1900.)—The author has completed a systematic study of the influence of the mast wire upon the intensity and the wave-length of the system of waves emitted by a Righi oscillator. He used a horizontal arrangement for the latter, and was thus enabled to attach auxiliary wires on both sides. He found that such an oscillator emits two superimposed wave trains, one of which has the same wave-length as that emitted by the oscillator without the wires, while the other has a greater wave-length, determined by the period of the whole oscillating system consisting of the balls of the oscillator and the wires joined by air sparks. The effect of the wires upon the original wave train of the oscillator is to strengthen it, since waves of the same length, but less damped, are emitted by the wires. The advantage of the wires increases as the air-gap separating them from the oscillator is diminished. As the air-gap increases the amplitude of oscillation of the whole system decreases in comparison with the amplitude of the original oscillation, and the damping factor increases. When one of the "feelers" was put to earth, and the other left in position, thus approximating to the arrangement used by Marconi, the second wave system could no longer be proved to exist. At least its wave-length could no longer be determined. Otherwise the phenomena were the same. E. E. F.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1850. *Hall Effect in Liquids.* **L. Amaduzzi** and **L. Leone.** (Accad. Lincei, Atti, 9. pp. 252–255, April 1, 1900.)—To decide the question whether the Hall effect is possible in liquids [see Abstracts Nos. 46 and 945 (1898)], the authors take a non-electrolytic liquid containing a substance which shows the Hall effect very strongly in the solid state. The liquid is an amalgam of bismuth. It shows the Hall effect very well, whereas pure mercury does not.



Instead of the cross used by Hall, Righi's arrangement was adopted as requiring less exact outlines. Two trapezes of plate glass were cut, A B C D (see diagram), B C being 5·1 cm. On one of them, a triangle E F G was painted with a commercial glue mixed with zinc oxide, and small plates of amalgamated copper were laid on at H, L, and M. The second glass was then put on top, and all the edges glued round with the same glue except A D. The trapeze was then exhausted and A D plunged into a 15 per cent. bismuth

amalgam which entered on readmitting the air and filled up all the space except the triangle E F G. A D was then also closed, and the trapeze then contained a layer of amalgam 0·02 mm. thick, bifurcated at B C. A current was sent from H through the two branches, and the two divisions of the current were balanced against each other.

The trapeze was exposed to a strong and uniform magnetic field, and it was then found that one branch of the current was increased at the expense of the other. On reversing the magnet, the balance of the two branch currents was also reversed, but the differences were not the same, owing to a difference of resistance produced by magnetisation, as in the case of solid bismuth. No such effects could be produced in pure mercury under the same circumstances. The results are not exact enough to give quantitative measurements, but they show at all events that the Hall effect is not inconsistent with the liquid state. E. E. F.

1851. *Break-Current in a Branch Circuit.* **K. R. Johnson.** (Ann. d. Physik, 2. 3. pp. 495–504, July, 1900.)—The author gives a mathematical treatment of the course of the current and potential in a broken circuit containing a branched portion. He shows that Edlund's theoretical views and experimental results are confirmed and explained. The spark at break may be eliminated by introducing a third branch free of inductance. [See also Abstracts Nos. 1302 and 1673 (1900).] E. E. F.

1852. *Thermo-electricity.* **C. Liebenow.** (Elektrotechn. Zeitschr. 21. pp. 246–249, March 22, 1900.)—General discussion of the history of thermo-electricity. Theory suggested that the E.M.F. in the circuit is a differential effect, the difference between two E.M.F.'s, each in its own unequally heated metal. F. Kohlrausch has already suggested this. If the smaller E.M.F. increase more rapidly than the larger under increase of temperature, we have the difference diminishing and ultimately a reversal of direction of the thermo-electric current. [For the mathematics of the subject see Verh. d. Deutsch. Phys. Ges., Bd. .I. pp. 74 and 82, 1899, Abstract No. 1515 (1899); and Wied. Ann. 68. p. 316, 1899, Abstract No. 1516 (1899).] If R is the electric resistance of the metal in ohms, L the heat conductivity in gramme-calories per second, and τ the absolute temperature of the warmer end of a bar of the metal, then the E.M.F. in volts between the two ends when these two ends differ in temperature by 1° C is

$$e = \pm 2{\cdot}04 \sqrt{RL\tau}.$$

If we measure L in electric units instead of gramme-calories, the factor 2·04 is omitted; and the $\pm$ sign shows that theory indicates nothing as to the direction of the E.M.F. The heat-conductivities of the metals are imperfectly known; but the values in Wüllner's table (Lehrb. d. Exp.-Physik, 5th. Ed. Vol. 3. p. 641) lead to e being 137½ microvolts in copper and 128 in iron. The difference between these is 9½ microvolts, as against 10 to 13 microvolts in the observed thermoelectric E.M.F. The electric resistance of iron increases more rapidly than that of copper; and the difference should disappear at 250° C., as against 270° C., the temperature of reversal. With most metals the results are concordant. Further, it appears that in all metals the hotter end is positive; in non-metals it is negative. If we combine a metal with a non-metal to form a thermoelectric couple, we ought to be able to make some use of the sum and not the difference of the two E.M.F.'s. If we could find a metal and an alloy in both of which the electric and the thermal con-

ductivities had the same ratio to one another, the full sum would be available; and with junctions at 1000° C and ordinary room-temperature, about 77 per cent. of the heat supplied to the hot junction would be in the first place converted into energy of current. About half this would, however, be lost in Joule effects, and the other half, say 38 per cent., would be available for the total circuit, but half of this would again be lost in Joule effects, leaving 19, or say 15, per cent. efficiency. This rate of efficiency would be most valuable, but the proper conducting materials are still to seek, so that the two E.M.F.'s may be opposed and as nearly as possible equal. A. D.

1853. *Effects of Strain on Thermo-electric Qualities.* **M. Maclean.** (Roy. Soc., Proc. 66. pp. 165–178, April, 1900.)—In a previous paper [see Abstract No. 1177 (1899)] an account was given by the author of his attempts to determine the magnitude of the thermo-electric effects obtained from any one metal strained and unstrained. A description of the continuation of similar experiments is given in this paper, the metals used being commercial and pure lead, annealed steel, aluminium and nickel. The method employed was to take a piece of the wire and draw it through a few holes of a draw-plate, so as to reduce its cross sectional area to about a quarter. The two pieces of wire, one drawn and one undrawn, were then joined, and observations were made on the currents obtained as the difference of temperature of the junctions was raised by successive steps to 100° C. The current in micro-amperes per degree up to 100° C being known and the resistance of the conductors measured, the thermoelectric difference per degree between drawn and undrawn wires is found. The results obtained were as follows :—

Steel, annealed	0·1028
Aluminium	0·0099
Nickel	0·3784
Lead, commercial	0·026
Lead, pure	0·0076

The numbers express the thermo-electric differences in micro-volts per degree C. diff. of temp. In the case of steel the values obtained were :—

1. Glass-hard steel 2. Unannealed steel	7·5	micro-volts per deg. C.
1. Unannealed steel 2. Annealed steel	0·18	„ „
1. Glass-hard steel 2. Annealed steel	7·67	„ „

Experiments were also made to determine the thermo-electric difference between free wires and wires previously permanently elongated by a longitudinal stress. The results are given in a table and include various kinds of copper, and reostene, platinoid, German silver, manganin, aluminium and nickel. Further experiments are next described on the thermoelectric differences between free wires and wires while (*a*) under stress within their limits of elasticity, and (*b*) under stress, stretching them beyond their limits of elasticity. It appears (1) that for small longitudinal strain in copper or in iron the direction of the current through the hot junction is the same, whether the force which produced the permanent strain is on or off; (2) that as the permanent elongation is increased, a stage is reached which gives zero

current when the forces are removed; and (3) that for greater longitudinal forces and permanent elongations the direction of the current is opposite, with the pulling forces off and on. Probably the permanent elongation must exceed a definite limit, to produce reverse thermo-electric effects with the longitudinal force on and removed.

The percentage elongations in the various cases, together with the thermo-electric differences in micro-volts per degree, are given in a set of tables.

J. J. S.

1854. *Conductivity of Gases from an Arc and from Incandescent Metals.* **J. A. McClelland.** (Cambridge Phil. Soc., Proc. 10. pp. 241–257, Jan., 1900.)—The first part of this paper contains an account of experiments on the conductivity of gas through which an arc discharge has passed; the second part refers to somewhat similar experiments on gas taken from the neighbourhood of an incandescent wire. In both cases the gas has considerable conductivity which can be shown to be due to ionisation, or a production in the gas of positively and negatively charged carriers of electricity. Experiments were made with the arc and with the incandescent wire in air, oxygen, and carbonic acid gas; the relation between current and E.M.F., the recombination of the carriers, the velocity of the carriers under electric force, and other points were investigated.

The conductivity of the gas was measured by observing the rate of leakage across it as indicated on a quadrant electrometer. As the E.M.F. increased the current across the gas, which at first was proportional to the E.M.F., approached a maximum value. The effects can be accounted for by supposing the discharge to take place by means of carriers of electricity. The velocity of the carriers varied greatly with the nature of the arc. In CO_2, as in air and oxygen, the velocity of the negative carrier is greater than that of the positive, the excess being about 25 per cent. in oxygen and 40 per cent. in CO_2.

Similar results were obtained when an incandescent wire was used to produce ionisation and render the gas conducting. J. J. S.

1855. *Electric Relations of Flame.* **P. Villard.** (Soc. Franç. Phys., Bull. 146. pp. 2–3, 1900.)—The gases of flame and the air which surrounds flame within from 2 to 3 decimetres are equalisers of potential when the flame is produced within an electric field and not otherwise, contrary to the received opinion. Various phenomena may be co-ordinated by supposing that flames, incandescent bodies and phosphorus, placed within an electric field, all emit kathode rays; and the bodies most readily discharged by the ultra-violet light are those which are most ready emitters of kathode rays in a vacuum tube. The formation of ozone would thus appear to be a direct consequence of the kathode radiation. The emission of kathode rays is accompanied by heating, which may even go on to incandescence; and that not merely in Crooke's tubes, but at higher pressures. A. D.

1856. *Influence of Proximity of Mass upon Electric Conductivity.* **G. Gore.** (Phil. Mag. 49. pp. 558–559, June, 1900.)—The proximity of a mass of lead weighing about 80 pounds was found not to have any perceptible influence on the resistance of a coil of copper or aluminium wire. T. M. L.

1857. *Hysteresis of Resistance.* **H. Chevallier.** (Comptes Rendus, 130. pp. 1612–1614, June 11, 1900.)—The author continues his previous work on

the influence of tempering upon the resistance of an alloy of platinum and silver [see Abstract No. 862 (1900)]. When the wire is subjected to a certain number of "disturbances" at the temperature T_2, alternating with a series of oscillations between two lower temperatures, T_0 and T_1, which are always the same, its resistance at T_0 tends towards a value which is called the "limit of limits" with respect to the temperature T_2. The value undergoes great variations when T_2 is as high as a bright red, and these variations obey different laws according to the temper of the wire. The temperature curve of these variations has the same general form both for a tempered and an annealed wire, with a maximum at about 325° and a minimum at about 470°. Neither of them is reversible, the returning line not coinciding with the outward line, but running below the former between 320° and 460°, and above it at temperatures below 320°. At temperatures between 460° and 700° the wire shows the least amount of this kind of hysteresis. E. E. F.

1858. *Compensation Resistance.* **T. Bruger.** (Phys. Zeitschr. 1. pp. 167–168, Jan. 6, 1900.)—The resistance-box described is intended to be direct-reading, and at the same time to work with switches instead of plugs, while keeping the total resistance constant. The total resistance of

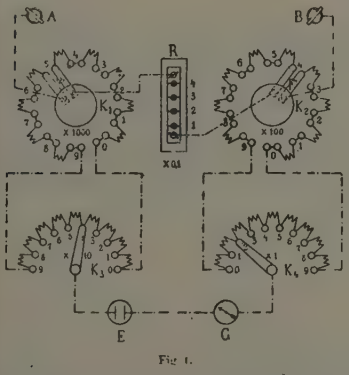


Fig. 1.

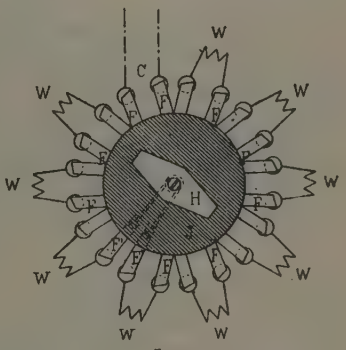


Fig. 2.

10,000 ohms is distributed over four switch rheostats, K, with the addition of a plug-box, R, for fractions of an ohm (Fig. 1). The construction of K_1 and K_2 is shown in Fig. 2, where F F F are double springs forming a metallic connection between successive coils, except F′F′, which are joined by the springs attached to the switch H. E. E. F.

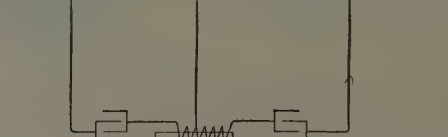
1859. *Simultaneous Testing for Fault Localisation.* **C. W. Schaefer.** (Electrician, 45. pp. 253–255, June 8, 1900.)—A description of practical examples of localisation of faults in cables by milliammeter readings taken simultaneously on board ship and ashore, the battery being applied at one end, and the conductor resistance being known, or ascertained at the time of test while the fault is sealed. The method is shown to be of value, especially with a variable earth fault, which, in the case quoted, changed from 700 ohms to 2·5 megohms. At the higher limit the opportunity was taken to measure the copper resistance, the true value of which of course is required for working out the results from the milliammeter readings at both ends. This is done by ordinary equations for derived circuits. In one instance

cited the position of the fault was localised within 100 ohms. of the actual spot, and in another within 12 ohms. The earth current is to be observed before testing, and allowed for unless very small, and the data required for calculation obtained from say half a dozen readings taken every fifteen or thirty seconds by prearrangement. In one case, where the fault was very variable, and caused by a piece of foreign matter in the guttapercha, the author thinks that no other method of localisation would have so well answered his purpose. E. O. W.

1860. *Kohlrausch Bridge Resistances.* **R. Abegg.** (Phys. Zeitschr. 1. p. 179, Jan. 13, 1900.)—Instead of adding equal resistances on each side of Kohlrausch's coiled bridge wire, the author adds a resistance of eight times the value of the bridge wire on one side, and a resistance equal to that of the bridge wire on the other side. In the arrangement VIII—I—Br, or Br—VIII—I, the first and last tenths of the bridge wire (Br) are increased in sensitiveness ten times, whereas, when the bridge wire is in the middle, the second and ninth tenths are similarly increased in sensitiveness. This is for most purposes more important than it is to increase the sensitiveness of the middle region. E. E. F.

1861. *A Capacity Meter.* **M. I. Pupin.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 189–191; Discussion, pp. 192–197, April, 1900.)—The theory is as follows: Referring to the diagram, *xy* is a conductor through which an alternate current is flowing. D is a condenser of known capacity, and E one that is unknown. F is a differentially wound telephone.

Connect as shown, and adjust resistances A B and B C, which must be inductionless until silence is obtained. Then capacity of D : capacity of E : :



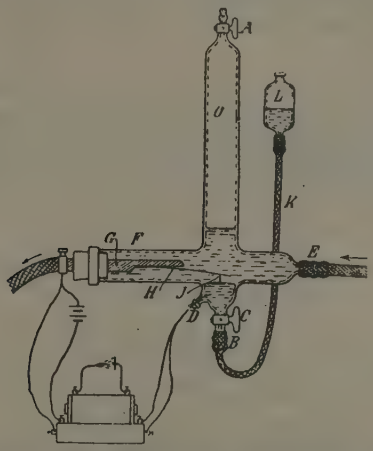
resistance of B C : resistance of A B. In place of a differential telephone an ordinary one can be put in the bridge B F.

A description of the apparatus is given, the alternating current being obtained from the secondary of a small induction coil provided with an interrupter such as is used in electrotherapy.

[This method was practically described in a paper by the abstractor read before the Physical Society, June 25, 1887, entitled, "Note on Comparing Capacities."] E. C. R.

1862. *Mercury Interrupter.* **E. Grimsehl.** (Elektrotechn. Zeitschr. 21. pp. 491–492, June 14, 1900.)—The author has designed a mercury interrupter on a novel and ingenious principle; he claims that it absorbs little energy and mercury, costs little, and is efficient on circuits provided with a low supply of power. The interruptions are produced by the reed of an organ pipe "blown" by a current of water, which serves the additional purpose of keeping the mercury clean and cool. The construction is shown in the

diagram, where G is the organ pipe, H the reed, J a platinum tip attached to it, O a cushion of air which serves to impart the necessary elasticity to the water, and E the tube through which the water flows in. The level of the mercury is regulated by the tap C and the reservoir L, connected to it by the flexible tube K. Interruption is very abrupt, owing to the high resistance of



the water, and the rate of interruption is of course much steadier than in the Wehnelt interrupter, but on the other hand it cannot be brought much higher than 100 per second. Any mercury carried off by the water can be collected in a wash bottle inserted in the water current. The platinum point shows very little wear, owing to the cooling effect of the water. E. E. F.

1863. *Wehnelt Interrupter Circuits.* **G. T. Hanchett.** (Elect. World and Engineer, 35. pp. 663–665, May 5, 1900.)—The author studies the indications of commercial electric measuring instruments when used on circuits containing a Wehnelt interrupter. The fact that direct-current instruments in the primary circuit give large deflections shows that the main current value predominates on one side of the zero line. The current wave is full of jagged peaks with greater rate of change on the decrease than on the increase. The formidable and unidirectional secondary discharge could not be otherwise accounted for. The voltage of supply can be measured with reasonable accuracy by any suitable commercial instrument. An indicating wattmeter of the dynamometer type will give approximate results on the various parts of the Wehnelt circuit. A calorimetric test of the interrupter will greatly assist in verifying this possibility. The inductive portions of the circuit generate a back electromotive force of self-induction, which, combined with the impressed electromotive force, produce a resultant often much larger than the total line voltage and undoubtedly lagging behind the pulsating impressed electromotive force. The electromotive force wave around the inductive resistance is filled with peaks of instantaneous maxima exceedingly steep and abrupt and nearly evenly divided on either side of the zero line. Around the interrupter is generated an electromotive force which combines with the impressed electromotive force, producing a resultant often very much larger than the line potential, and leading the impressed pulsating

electromotive force. Direct-current instruments may possibly be relied on to measure the total voltage of the Wehnelt circuit and the current flowing therein. They take no heed whatever of any alternating resultants due to self-induction or capacity or similar effect, but approximately follow Ohm's law throughout the circuit. The alternating-current dynamometer voltmeter does take account of the alternating resultants around various portions of the circuit and gives an approximate idea at least of the square root of the mean square value. E. E. F.

1864. *Damping of Galvanometer Needles.* **M. Solomon.** (Phil. Mag. 49. pp. 559–570, June 1900. Paper read before the Physical Society of London.)—In the motion of a galvanometer needle under the retarding forces of the controlling field, of eddy currents in neighbouring metallic masses, and of air friction, the time for the reduction of the deflection to $1/m$ of its original value, is given by $\tau = 1/2 \log_e m \frac{t}{\lambda}$,

where— $$\frac{t}{\lambda}, \text{ or } \frac{\text{period}}{\text{logarithmic decrement}} = 4\frac{I}{N}$$

(I = moment of inertia, and N = resistance to the motion of the needle), provided the assumption be made that the retarding forces are proportional to the first power of the velocity. Making this assumption, therefore, $\frac{t}{\lambda}$ and τ are independent of the strength of the controlling field.

The author has made experiments on various galvanometers to determine whether this result is borne out in practice. He varied the strength of the controlling field, measuring this by the period of the galvanometer, and gives tables showing the variation of the ratio t/λ with the period. In every case the ratio was found to increase with the period. Experiments were then made with a galvanometer free from any masses of metal which could be the seat of eddy-currents. With the circuit of the galvanometer coils open the ratio t/λ was constant for periods of from 2·5 to 17·5 seconds; when eddy-current damping was introduced by short circuiting the coils, the ratio increased by about 9 per cent. for the same variation of period.

As the damping effect of eddy-currents is proportional to the square of the needle strength, the author concludes that the increase of the ratio with increasing period, *i.e.*, with decreasing strength of controlling field, is due to variations in the strength of the needle consequent on variations in the controlling field. G. H. B.

1865. *Use of Braun's Kathode Ray Tube for Alternate-current Curves.* **H. J. Oosting.** (Phys. Zeitschr. 1. pp. 177–179, Jan. 13, 1900.)—When alternate-current curves are traced by means of the Braun tube [see Abstract No. 1,095 (1900)], a difficulty is presented by the intermittent character of the kathode rays, and another by the necessity of securing synchronism between the alternator furnishing the current and the revolving mirror. These difficulties have been overcome by the author by the expedient of mounting the sensitive curve paper direct on the shaft of the alternator, thus dispensing with the mirror altogether, and securing perfect synchronism between the revolution of the curve paper and the deflection of the kathode beam. The deflections must of course be parallel to the axis of the shaft. The successive curves are then superimposed upon each other, and both the discontinuity and the photographic feebleness of the kathode

rays are met. If several successive alternations are to be obtained in one revolution, the recording paper or film can be mounted on an auxiliary shaft driven by the first through some suitable gear. The exposure depends upon the strength of the rays, the velocity and diameter of the shaft, and the tracing medium used. With a Wimshurst machine to generate the rays, the author obtained a good record on bromide paper in five minutes, and on an Eastman film in one minute. E. E. F.

ALTERNATING CURRENTS AND MAGNETISM.

1866. *Expression of Power in Alternating Current Circuits.* **H. Sire de Vilar.** (Écl. Électr. 23. pp. 246–252, May 19, 1900.)—A simple harmonic function can always be transformed into an exponential function thus—

$$\cos x = \frac{1}{2}\left(e^{ix} + e^{-ix}\right), \text{ where } i = \sqrt{-1}.$$

The harmonic function—

$$y = A\cos(\omega t + \phi)$$

can be written—

$$y = \frac{A}{2}\left\{e^{i\omega t + i\phi} + e^{-i\omega t - i\phi}\right\}$$

$$= \frac{A}{2}\left\{e^{i\phi}e^{i\omega t} + e^{-i\phi}e^{-i\omega t}\right\}$$

Now consider two harmonic functions—

$$y_1 = \frac{A_1}{2}e^{i\phi_1}e^{i\omega t} + \frac{A_1}{2}e^{-i\phi_1}e^{-i\omega t}$$

$$y_2 = \frac{A_2}{2}e^{i\phi_2}e^{i\omega t} + \frac{A_2}{2}e^{-i\phi_2}e^{-i\omega t}$$

Their product is—

$$y_1y_2 = \frac{A_1A_2}{4}e^{i(\phi_1+\phi_2)}e^{2i\omega t} + \frac{A_1A_2}{4}e^{-i(\phi_1+\phi_2)}e^{-2i\omega t}$$

$$+ \frac{A_1A_2}{4}e^{i(\phi_1-\phi_2)} + \frac{A_1A_2}{4}e^{-i(\phi_1-\phi_2)}$$

The same result is arrived at by decomposing into its vector constituents each of the real terms of the product y_1y_2.

We see that y_1y_2 is half the sum of two imaginary conjugates.

Here we agree to take one of these vectors to represent y_1y_2 and put—

$$(y_1y_2) = \frac{A_1A_2}{2}e^{i(\phi_1+\phi_2)}e^{2i\omega t} + \frac{A_1A_2}{2}e^{i(\phi_1-\phi_2)}$$

If from the instantaneous products we pass to the mean products over a period, we get—

$$\frac{1}{T}\int_0^T (y_1y_2)dt = \frac{A_1A_2}{2}e^{i(\phi_1-\phi_2)}$$

If in place of the amplitudes we consider the virtual values, we get—

$$\frac{1}{T}\int_0^T (y_1y_2)dt = A_1A_2e^{i(\phi_1-\phi_2)}$$

We thus obtain the imaginary expression of the power already found by Steinmetz.

$$\frac{1}{T}\int_0^T (y_1 y_2)dt = A_1 A_2 \left\{ \cos(\phi_1 - \phi_2) + i \sin(\phi_1 - \phi_2) \right\}$$

The first term—

$$A_1 A_2 \cos(\phi_1 - \phi_2)$$

is the real power, and the term—

$$A_1 A_2 \sin(\phi_1 - \phi_2)$$

is the wattless power.

We note that if in the product $y_1 y_2$ we had neglected the second imaginary instead of the first, we should have represented $y_1 y_2$ by—

$$(y_1 y_2) = \frac{A_1 A_2}{2} e^{-i(\phi_1 + \phi_2)} + \frac{A_1 A_2}{2} e^{-i(\phi_1 - \phi_2)}$$

and the integral would then be—

$$\frac{1}{T}\int_0^T (y_1 y_2)dt = \frac{A^1 A_1}{2} e^{-i(\phi_1 - \phi_2)}$$

$$= \frac{A_1 A_2}{2} \left\{ \cos(\phi_1 - \phi_2) - i \sin(\phi^1 - \phi_2) \right\}$$

In the other terms the real power remains the same and the wattless power changes in sign. W. G. R.

1867. *Permanent Magnets and Temperature Coefficients.* **I. Klemenčič.** (Akad. Wiss. Wien, S.ber. 108. pp. 491–510, and 989–1000, 1899.)—Eighteen pieces of steel of square section were magnetised in a uniform field of 8·65 units and their temperature coefficients (β) were measured by means of a magnetometer and compensating coil. The temperatures ranged from 2° to 35° and the specific resistance (σ) was measured at the ends and middle in order to judge the hardening. It is shown that β is inversely proportional to the quantity, length / breadth (l/b). The results obtained for one specimen 4 mm. broad are given in the following table :—

l nearly.	β	Mean temp.	l/b	$\beta \times l/b \times 10^4$
cm.				
4	0·000437	19·5	9·9	42·2
6	301	19·5	15·2	46·5
8	213	19·8	20·6	43·7
10	176	19·7	25·4	44·8
15	135	20·8	37·7	51·8

The induction coefficients were determined, in various fields and for magnetic and unmagnetic conditions, of the same steel bars as were used in the determination of the temperature coefficients. If μ and μ_0 represent the changes in magnetic moment per gramme per unit field in magnetised and unmagnetised conditions respectively, μ_0 is found to be greater than μ when the dimension-ratio of the magnet (length/breadth) varies between 40 and 15, and for dimension-ratios between 15 and 5, μ and μ_0 are practically equal. So

far as the experiments go, these coefficients do not change with the field strength, but vary in the same sense as the dimension-ratio. A series of experiments (on magnetisation) in which the same bars were tested, first, by withdrawing the magnetising force suddenly, and, second, by reducing it gradually to zero, shows that, except when the dimension-ratio is very small, there is very little to be gained by magnetising by the second method. The increase obtained by the second method is more marked when the sectional area is large. G. E. A.

1868. *Condenser Currents in Symmetrical Polyphase Systems and their Graphical Representation.* **C. E. Guye.** (Écl. Électr. 23. pp. 408–415, June 16, 1900.)—The author states that the high voltages now used in power transmission schemes make the problem of the condenser currents in a polyphase system one of great importance. He shows how to calculate the condenser currents in the case when we have two, three, or four conductors symmetrically placed inside a hollow cylindrical conducting sheath, when everything is symmetrical and the E.M.F.'s follow the harmonic law. In the case of a three-phase system, for example, we can calculate the condenser currents on the supposition that we have a condenser of capacity K connecting each main to the sheathing [see 1900, Abstract No. 1308]. The calculation of K presents very great difficulty, but it can easily be determined practically as follows. First measure the capacity (K_1) between the three conductors in parallel and the outer sheathing in the ordinary way by a ballistic galvanometer and a standard condenser. Next measure the capacity (K_2) between one of the conductors and the other two joined to the sheathing. Then the author proves that—

$$K = \frac{9\,K_2 - K_1}{6}$$

The following data concerning three three-phase high tension conductors are given by M. Revillod, of the Berthoud Borel Cable Company at Lyons :—

	1st cable.	2nd cable.	3rd cable.
Working pressure in volts	10,000	10,000	20,000
Section of conductor in sq. mms.	85	140	50
Diameter of conductor in mms.	13·1	16·65	13·85
Length of cable in kilometres	5 (about)	11	0·1
Minimum distance between conductor and sheathing in mms.	9	9	18
Minimum distance between two conductors in mms.	10·5	10·5	18
Capacity per kilometre between three conductors in parallel and sheathing (K_1) in microfarads	0·282	0·314	0·204
Capacity per kilometre between one conductor and the other two and the sheathing in parallel (K_2)	0·143	0·166	0·095

The values of K calculated for the three cables are given as 0·1675, 0·1967 and 0·108 respectively. These values are all about 13 per cent. greater than K_2. A. R.

1869. *Permanent Magnets.* **H. Frank.** (Ann. d. Physik, 2. 2. pp. 338–358, June, 1900.)—A number of magnets were prepared of the same piece of

English silver steel. They were chilled from several high temperatures ranging from a dull red to a white heat, and then magnetised by the same current and coil. The highest magnetic moments were shown by those magnets which had been chilled from a normal red heat, midway between the dull red and the white. The influence of the temperature is very considerable. Thus the moment obtained after heating to normal red is double that obtained after heating to dull red, and 30 per cent. higher than that obtained after heating to a white heat. The duration of the heating, however, seems to have no influence whatever. The temperature at which the magnetisation itself is carried out is also of importance. If carried out at a low temperature, the moment obtained is higher than if the magnetisation takes place at, say, 100°. But the difference is very slight when the steel has been chilled from a bright red or a white heat. The "loose magnetism" is more easily got rid of when the chilling takes place from a low heat than from a high one, and Barus and Strouhal's methods of ageing magnets either by boiling or by cycles of temperature appear to be the best all round. E. E. F.

1870. *Atomic Magnetism.* **R. Lang.** (Ann. d. Physik, 2. 3. pp. 483–494, July, 1900.)—The author interprets the amperian molecular currents as convection currents produced by the revolution of negative electrons as satellites round the heavier positive electrons. On the supposition that the periodic time of such an electron cannot be the same as the vibration period of visible light without giving rise to luminous effects, he arrives at a period which is more rapid than that of ultra-violet light, and leads to no contradictions. The periodic time is about 10^{-19} sec., the diameter of the orbit about 10^{-9} cm., and the magnetic moment of a divalent iron atom comes out as $8{\cdot}6 \times 10^{-20}$ c.g.s. units. This would give for the saturation moment of a cubic cm. of normal $FeSO_4$ solution the value of 4·6 c.g.s. units. This agrees so closely with Jäger and Meyer's experimental value of 1·6 units that the attempt to bring theory and experiment into harmony along the lines indicated is permissible. Since the same value applies to the solutions of cobalt, nickel, and manganese sulphates, and yet the atomic susceptibilities of nickel, cobalt, iron, and manganese are as 2:4:5:6, the author suggests that this diversity may be due to differences in the number of free valencies, such as are suggested by the different number found to occur in each. If the free valencies alone have a determining influence upon molecular magnetic susceptibilities, then chemical combination may very conceivably exert an influence upon the magnetic properties of a substance. This would explain why the oxides of some paramagnetic metals are diamagnetic.

It is not necessary to assume that the negative satellites are always associated with the same positive electron. If their velocity becomes very great they may fly off and revolve round another positive electron. Their usual velocity is that of light. Ordinarily, the projection of an electron beyond the surface into a surrounding dielectric produces a strong difference of potential which hinders further losses. But if the surrounding medium is a dielectric, and the difference of potential is equalised as soon as established, a continuous current may be set up. This takes place in Hurmuzescu's experiment, in which two iron wires are immersed as electrodes in a solution of acetic or oxalic acid, and one of them is magnetised. It appears that when the magnetic field is such that the lines of force do not leave the surface vertically, negative electrons are shot off into the liquid, owing to the plane of their orbits being inclined to the surface of the iron. E. E. F.

MEDICAL ELECTRICITY.

1871. *The Radiogoniometer.* **Guilleminot.** (Archives d'Él. Médicale, 8. pp. 158–170, April, 1900.)—The angle at which the Röntgen rays strike the part to be photographed can be determined by the instrument named above, and secondarily the position of the tube can be adjusted by its use so as to bring the tube into the most favourable position. The principle of the instrument is that of a fixed wire cross and a movable one ; the latter is so adjusted that the shadows of both upon a fluorescent screen coincide, and the angle is then read off by means of divided arcs of circles. By a sighting arrangement, or by a rigid metal rod, the line of incidence can be found and marked upon the surface of the subject's body. The author's couch is a double decked arrangement, the tube being fixed to the roof. Two figures are given. H. L. J.

1872. *Complete Electrotonus.* **Mlle. I. Ioteyko.** (Archives d'Él. Médicale, 8. pp. 149–152, April, 1900.)—An article describing experiments upon the production of electrotonus in the exposed sciatic nerve of the frog. When a current of 0·0002 ampere is caused to traverse a short length of the nerve, a state of anelectrotonus is set up round the position of the anode and produces at that point a complete block to the transmission of impulses along the nerve. H. L. J.

1873. *Electro-Therapeutics.* **H. L. Jones.** (Inst. Elect. Engin., Journ. 29. pp. 346–366 ; Discussion, pp. 366–381, April, 1900.)—The author gives a short account of the elements of electro-therapeutics. He describes the manner in which muscles and nerves respond to electrical stimulation, and proceeds to explain, as well as is possible to a non-medical audience, some of the principles of electro-diagnosis. Coming next to the question of treatment, he states that progress moves along in two lines—one of these is based on experimental physiology, the other is by direct experiment in a more or less haphazard manner on the sick. He then defines the limits in which electricity is useful in paralysis and the relief of pain ; and refers to the cataphoric introduction of drugs, as well as to the usefulness of electrolysis in minor surgery. Electrodes, batteries, &c., are then discussed, and lastly Röntgen ray work, as developed by medical practitioners, is briefly touched upon. W. S. H.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1874. *Distillation of Amalgams and Purification of Mercury.* **G. A. Hulett.** (Zeitschr. Phys. Chem. 33. pp. 611–621, June 1, 1900.)—The presence of 1 part of zinc in 10^{-8} parts of mercury can be detected by adding the amalgam to pure mercury in the combination Hg/HgO in aqueous CO_3/Zn, the E.M.F. being immediately lowered if any trace of zinc is present.

V. Meyer has stated that mercury requires twelve distillations in order to free it from metallic impurities; this is due to the fact that the boiling usually takes place with considerable bumping. If, however, the distillation is carried out in a mercury-vacuum or in a current of an indifferent gas, the mercury evaporates quietly, and a complete purification can be effected in one distillation, using merely two Wurtz flashes as boiling-flash and receiver. If zinc oxide is present with the amalgam it is carried over mechanically in the form of dust, but no metallic zinc is present in the distilled mercury, which merely requires filtering to free it from all traces of zinc. Using a water-pump to exhaust the receiver, the mercury boils at 210°, and since no zinc can be detected in the distillate, the vapour pressure of zinc at this temperature must be less than $\frac{1}{2} \times 10^{-7}$ of that of mercury at the same temperature. T. M. L.

1875. *Vapour-density of Bromine at High Temperatures.* **E. P. Perman** and **G. A. S. Atkinson.** (Zeitschr. Phys. Chem. 33. pp. 577–578, June 1, 1900.)—C. Langer and V. Meyer have determined the vapour density of bromine-vapour at 900° when diluted with eleven times its volume of nitrogen; the value obtained was 5·459 (air = 1) or 78·88 (hydrogen = 1), and compares closely with that given by the authors [see 1900, Abstract No. 1518] for pressures between 365 and 767 mm. This confirms the conclusion that the degree of dissociation is, at this temperature, only slightly influenced by the pressure. T. M. L.

1876. *Liquid Crystals.* **O. Lehmann.** (Deutsch. Phys. Gesell., Verh. 2. 6. pp. 72–76, 1900.)—The only definition of a crystal to which no objection can be taken is one based on the fact that, during crystal growth, the new layers deposited are regularly orientated with regard to the particular type of anisotropy present in the crystal. This regular deposition may be considered as due to a certain molecular force to which the author gives the name "molecular directing-force (*Richtkraft*)," and which is not identical with elasticity, as is evident from a study of azoxyanisol and azoxyphenetol, which form liquid crystals having no elasticity. The molecules in these crystal drops strive to arrange themselves parallel to the surface; the anisotropy of the molecules corresponds to the monosymmetric system, and it must be assumed that, in the interior of the crystal drops, the molecules are arranged on concentric spherical surfaces around a common axis of symmetry. With a drop resting on a flat surface the latter is perpendicular to the axis, whilst if the drop be pressed between two flat plates the axis lies parallel to the pressing surfaces. In the direction of the axis a crystal drop has the appearance of a point-like nucleus surrounded by a circular halo, and perpendicular to the axis it looks as though the drop contained a lens standing on its edge. In polarised light the drops show a colourless-yellow dichroism, and between

crossed nicols whose principal directions of vibration coincide with those of the molecules, they appear dark or more frequently coloured, since for one particular colour there is usually circular polarisation due to the superposition of differently orientated molecules. In the magnetic field (strength 3,000–8,000) the axis endeavours to place itself parallel to the lines of force, but complete compensation of the molecular directing force by the magnetic force could not be obtained with the strengths of field used. If two liquid drops flow together, a drop is first formed having two round nuclei and a four-angled convergence-point corresponding to the centre of the system of lemniscates, which then determines the arrangement of the molecules; two drops may also be arranged concentrically. By the aggregation of several drops with axes perpendicular to the flat supporting surfaces, the number of convergence-points is always one less than that of the points of symmetry. If, however, several drops are pressed between two surfaces—their axes being hence parallel to these surfaces—when they flow together their poles show a tendency to approach one another and join.

Since all possible intermediate forms between crystal drops and solid crystals are conceivable, the term "solid" must be omitted from the definition of a crystal. Liquid crystals can be arranged in the various crystalline systems, and although in general they do not possess a polyhedral shape owing to surface-tension effects, yet these latter can be removed, and liquid crystals with molecules arranged in parallel rows obtained. T. H. P.

1877. *Reciprocal Action and Equilibrium between Trigonal Pole-systems: Theory of Crystal Structure.* **E. Riecke.** (Phys. Zeitschr. 1. pp. 277–282, March 24, 1900.)—The author considers an electric pole-system consisting of a regular hexahedron at the angles of which are alternately positive and negative poles of equal strength. From such trigonal pole-systems molecule-lattices can be constructed, having the symmetry corresponding to the sphenoidal-hemihedral division of the hexagonal system, and to a certain extent to that of trapezohedral group of the same system. The action between the pole-systems and the conditions of equilibrium of the lattices are treated mathematically, so that the paper does not admit of a satisfactory abstract.
T. H. P.

1878. *Hydration of Dissolved Substances.* I. **W. Nernst.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 1. pp. 68–69, 1900.) II. **H. Lotmar.** (*Ibid.*, pp. 70–85, 1900.) III. **C. C. Garrard** and **E. Oppermann.** (*Ibid.*, pp. 86–89, 1900.)—I. The question as to whether, when a substance is dissolved, combination occurs between the solvent and the solute, *i.e.*, the validity of the so-called hydrate theory of solution, cannot be solved by a study of osmotic pressure or of any other phenomenon in which a state of equilibrium in solution is arrived at. For this purpose dynamical phenomena must be considered, since, if the dissolved substance is displaced in the solution, any combined solvent will be carried along with it. The only means of detecting such displacement is by adding some third substance to the solution, and then studying for instance the movement of the dissolved body on diffusion or on electrolysis. The added substance must not be capable of combining with the dissolved body. In the two following abstracts the results of experiments on these lines are given, the conclusion being that in general hydration of the solute is either entirely absent or only takes place to a very limited extent.

II. **H. Lotmar.** From diffusion experiments on solutions of silver nitrate, butyric, acetic and boric acids, the author concludes that the supposition of Mendelejeff and of Pickering that dissolved substances undergo considerable hydration is not correct, since in all cases he finds that the number of molecules accompanying a molecule of diffused substance is very small. The results show further that for every molecule of silver nitrate or acetic acid diffusing in one direction a number of molecules of water diffuse in the opposite direction; this lends confirmation to the view that diffusion is a complex process in which the solvent takes part. In the cases named this diffusion of the solvent is sufficient to overbalance any slight hydration of the dissolved substance which may occur.

III. **C. C. Garrard** and **E. Oppermann.** The authors describe a number of experiments on the electrolysis of solutions of an electrolyte containing also a non-electrolyte. Dilute solutions of hydrochloric, hydrobromic, nitric and sulphuric acids were employed, the non-electrolytes added being sugar, phenol, urea, and acetic acid. The results are not very concordant, but serve to show that the negative ions, Cl, Br, NO_3, SO_4, take with them, in their passage through the decomposing liquid, a number of molecules of water which is least for the nitrate and greatest for the sulphuric residue. T. H. P.

1879. *Stassfurt Salt Deposits and Hydrated Sulphates of Calcium.* **J. H. van't Hoff** and **E. F. Armstrong.** (Preuss. Akad. Wiss. Berlin, S.ber. 28. pp. 559-576, May 31, 1900.)—In a former paper [see Abstracts Nos. 226 and 1114 and 1116 (1900)] the conditions were investigated under which the calcium sulphate deposits were formed, without paying particular attention to its state of hydration. In the present investigation the authors have experimented on the conditions necessary for the deposit of calcium sulphate as gypsum $CaSO_4.2H_2O$, as half-hydrate $CaSO_4.\frac{1}{2}H_2O$, or in the anhydrous form $CaSO_4$. The problem resolves itself into measuring the tension of the water of crystallisation in the crystal at different temperatures; for, if the solution pressure lies between the pressure of gypsum and half-hydrate, then the latter will be the stable form of the salt.

The experimental method finally adopted consisted in measuring the boiling point of a solution of sodium or magnesium chloride which contained gypsum. If more chloride is added, then the boiling point will be raised, provided the gypsum is not giving up any of the water of crystallisation. More and more chloride is added and the boiling point raised until at a certain temperature it becomes constant for a time in spite of the continued addition of chloride. This point corresponds to the conversion of gypsum into half-hydrate and water at the barometric pressure. By enclosing the apparatus and working under reduced pressures a curve can be drawn of the variation of the pressure in the gypsum crystal with temperature. The results of the experiments are plotted in curves in the paper, and the following formula is deduced—

$$\log p_g = \log p_w + 1{\cdot}493 - \frac{567{\cdot}7}{t + 273}$$

where p_g is the pressure in the gypsum crystal and p_w the maximum vapour pressure of water both at the same temperature t. J. B. H.

1880. *Driving Energy of Physico-chemical Reaction.* **T. W. Richards.** (Amer. Acad., Proc. 35. pp. 471-480, May, 1900.)—In van't Hoff's equation $d \log K/dT = U/RT^2$ the general form of K is $\Pi c_1^{\nu_1}/\Pi c_2^{\nu_2}$ or $\Pi v_2^{\nu_2}/\Pi v_1^{\nu_1}$, wherein

U denotes the diminution of intrinsic energy during isometric reaction, c the concentration of any component, v its specific volume, n the number of its reacting gram-molecules, and the subscripts 1, 2 refer respectively to the factors and products of the reaction, while Π signifies the product of all the magnitudes of the given type. On substitution from the gaseous relations of type $c = v^{-1} = p/RT$ the equation becomes

$$d \log (\Pi p_1^{n_1} / \Pi p_2^{n_2}) / dT = V/RT^2,$$

where $V \equiv U - (\Sigma n_2 - \Sigma n_1)RT$ is the heat of isopiestic reaction ; and of this Clausius' equation, $d \log P/dT = \lambda/RT^2$, is a special case.

The former equation having been called the "reaction-isochor," the author terms the latter the "reaction-isobar," and he includes both in a "reaction-metatherm"

$$d \log (T^N \Pi p_1^{n_1} / \Pi p_2^{n_2}) / dT = -Q/RT^2,$$

where N is defined by $N \equiv \mathfrak{N}(P_2 - P_1)/P_1$; herein Q denotes the actual heat *absorbed* in the reaction, $\mathfrak{N}$ the total number of gram-molecules in the initial reacting mixture, P_1, P_2 the initial and final total gaseous or osmotic pressures.

This equation is taken to be a mathematical expression of the theorem of Maupertuis or Le Chatelier, and is further written in the form

$$d \log (T^N \Pi z_2^{n_2} / \Pi z_1^{n_1}) = -Q/RT^2,$$

a train of ideas having caused the author to *assume* that each substance in the mixture has a special "physico-chemical potential" z such that

$$\Sigma n_1 \log (p_1 z_1) - \Sigma n_2 \log (p_2 z_2) = 0,$$

and such too that $\log z^n$ is a measure of the special reaction-tendency of the substance. The equation then shows that a reaction which absorbs heat will have a greater tendency to take place if the temperature is raised.

An application of this theory to certain special cases is then indicated.

R. E. B.

1881. *Physical Reactions and the Mass Law.* **A. T. Lincoln.** (Journ. Phys. Chem. 4. pp. 161–187, March, 1900.)—Bancroft has extended the law of mass action to "physical reactions" by making use of fractional, in place of integral, indices. The formula

$$\frac{xy^{n-1}}{z_1^n} = C,$$

given by Taylor (Journ. Phys. Chem. 1. 30, 1897), can be used to represent the weights or volumes of water (x), benzene (y), and alcohol (z) which are present when two liquid layers are about to appear or disappear in a mixture of the three substances in different proportions. In the present investigation it is shown that Taylor's formula gives exceedingly accurate results, especially when the mixtures are prepared gravimetrically, the deviations being usually less than one-third per cent. For both weights and volumes $n = 1{\cdot}525$, and, as Taylor showed, this constant does not depend on the temperature ; $c = 0{\cdot}4949$ for gravimetric measurements at 25° C, and $0{\cdot}5767$ at 10° C.

T. M. L.

1882. *The System Water, Phenol, and Hydrochloric Acid.* **W. H. Krug** and **F. K. Cameron.** (Journ. Phys. Chem. 4. pp. 188–192, March, 1900.)—The temperature at which phenol melts under water is raised by the addition of hydrochloric acid (Bancroft, Journ. Phys. Chem. 1. 420, 1897) and quantitative measurements are now given. The melting point is raised from 1·365° to 2·298° by 3·4028 grams HCl per litre, to 4·000° by 13·1323 grams, to 7·100° by 32·8514 grams, and to 17·195° by 131·3234 grams. T. M. L.

1883. *Refractometric Determination of the Composition of Coexistent Phases in Mixtures of Acetone and Ether.* **E. H. J. Cunaeus.** (Phys. Zeitschr. 1. pp. 316–317, April 14, 1900.)—The external pressure was altered, and the composition of the vapour ascertained by determining its refractive index by means of Rayleigh's interferential method, assuming the validity of the law of mixtures, and making allowance for the deviations from Boyle's Law. The composition of the liquid was known from the initial weighings and the quantity of vapour present. The results are given in a short table, from which it appears that there is no maximum or minimum of vapour-pressure. The experimental data are not in accordance with the formula given by van der Waals (Archiv. Néerl. 24. p. 44). F. G. D.

1884. *Distillation of Liquid Air and Composition of the Gaseous and Liquid Phases.* **E. C. C. Baly.** (Phil. Mag. 49. pp. 517–529, June, 1900. Paper read before the Physical Society of London.)—Liquid mixtures of oxygen and nitrogen were allowed to boil in vacuum-jacketed vessels. At successive points of time samples of the gas were collected for analysis and simultaneous readings of a Callendar's compensated hydrogen-thermometer taken. The bulb of the latter dipped into the liquid. The composition of the boiling liquid at successive moments was ascertained by sucking it out through a capillary tube attached to a water-pump. This tube was provided with a T-piece, so that samples of the gas resulting from the *en masse* vaporisation of the liquid could be collected for analysis. Corresponding temperature-measurements were also made. The results so obtained are plotted in a diagram with absolute temperatures as ordinates and oxygen-percentages as abscissæ. In this diagram the corresponding compositions of the gaseous and liquid phases can be seen at a glance, and its employment enables one to determine the temperature of a given sample of liquid air boiling in a vacuum-vessel by an analysis of a sample of the gas given off.

When the logarithms of the ratios of oxygen to nitrogen in each phase are plotted against each other, the points so obtained lie almost exactly on a straight line, *i.e.*, the equation $\log r' = a + b \log r$ holds, where r' and r denote the ratios just mentioned. In the present case it is found that $r' = 0{\cdot}2097\ r^{1{\cdot}06737}$, in which r' and r represent the above ratios multiplied by 100. This is, of course, only an empirical formula, and does not hold at the extreme limits. The boiling points of oxygen and nitrogen as determined by the author are 90·96 and 77·54 respectively ($p = 760$ mm.). The vapour-pressures of oxygen and nitrogen were calculated for every half degree between the above temperatures from the author's boiling-point and vapour-pressure measurements by means of Ramsay and Young's linear law. Reference is made to the extraordinary tendency to superheat which liquefied gases exhibit even when "boiling" fairly rapidly. F. G. D.

1885. *Heat of Ionisation.* **R. Abegg.** (Phys. Zeitschr. 1. pp. 212–213, Feb. 10, 1900.)—Great heats of dissociation are due to intramolecular chemical

reactions such as isomerisation, polymerisation, and hydration, which depend upon ionisation. Hence water has the greatest heat of dissociation, about —13,000 calories, and the formation of H and OH ions is preceded by depolymerisation. Among acids, violuric acid has the high heat of dissociation of —3,700 calories. This is in accordance with Guinchard's observation that it undergoes an intramolecular change previous to ionisation, and that its conductivity, and hence also its dissociation constant, has a high temperature coefficient. E. E. F.

1886. *Taste of Acids and Ionisation.* II. **T. W. Richards.** (Journ. Phys. Chem. 4. pp. 207–211, March, 1900.)—It has been shown that weak acids and acid salts have a more strongly acid taste than is demanded by their degree of dissociation, on the assumption that the sourness is caused by hydrogen ions. This can be explained either by supposing that the undissociated molecules and anions contribute to the taste, or by supposing that owing to chemical action at the nerve-endings on the tongue-surface the hydrogen ions are removed from the sphere of action, and their place consequently taken by fresh ones owing to the dissociation-equilibrium. Ionisation being an excessively rapid process, a weak acid might accordingly cause a degree of sourness out of all proportion to its strength. The author inclines to the latter explanation as the true one [see also Abstracts Nos. 535 (1898), and 1326 (1900)]. F. G. D.

1887. *Absorption of Nitrogen and Hydrogen by Solutions of Ionised Substances.* **L. Braun.** (Zeitschr. Phys. Chem. 33. pp. 721–739, June 15, 1900.)—It has been shown by Jahn that if α and α' represent the absorption coefficients at the same temperature of a gas in water and in an aqueous solution of an electrolyte containing G gramme-molecules of dissolved substance per unit volume, respectively, then the value of $(\alpha - \alpha')/G^{2/3}$ is constant. Roth found this relation to hold for the absorption of nitrous oxide by solutions of phosphoric acid and sodium chloride, and showed further that by applying Planck's equilibrium law to dilute solutions of gases in solvents having no chemical action on them, the relation $C_1/C_2 = 1$ can be derived; C_1 and C_2 being the molecular concentrations of the gas in pure aqueous solution and in a solution of the indifferent substance respectively—temperature and partial pressure being identical in the two cases. The author's investigations on the absorption of nitrogen and hydrogen by solutions of the non-electrolytes, urea and propionic acid, and of the electrolytes, sodium and barium chlorides, show that for non-electrolytes the equation $C_1/C_2 = 1$ holds with a fair degree of accuracy even for concentrated solutions. For solutions of the two chlorides the value of C_1/C_2 is for medium concentrations considerably greater than 1, and only attains this ideal value for very dilute solutions; the results are, however, in complete accord with Jahn's empirical law: $(\alpha - \alpha')/G^{2/3}$ = a constant. Also for solutions of the same electrolyte, the ratio of the values of this expression for nitrogen and hydrogen is constant at all temperatures (5° to 25°); this is not the case for nitrous oxide and nitrogen, or nitrous oxide and hydrogen. T. H. P.

1888. *Degree of Ionisation and Ionisation-Equilibrium in Strongly-Ionised Electrolytes.* Part I. **H. Jahn.** (Zeitschr. Phys. Chem. 33. pp. 545–576, June 1, 1900.)—Regarding the well-known disagreement between theory and experiment in the case of the dissociation-equilibrium in highly-dissociated electrolytes as due to the influence exerted on the nature of the solvent medium by

the enormous ionic charges, the author points out that this influence is likely to affect the mobility of the ions, although its effect has been usually sought for in an alteration of the dissociation-equilibrium. The object of the present paper is to find out if the mobilities of the ions are functions of the ionic concentrations. Having pointed out the error involved in the usual determination of degree of ionisation from conductivity measurements if such be the case, the author proves the equation $UC = 1{\cdot}0358\frac{n \times k}{\nu} \times 10^{-2}$, where U = mobility of kation (*i.e.*, velocity of kation under a potential-gradient of 1 volt per cm.), C = concentration of kations (in grm. mols), n = migration-constant of kation, k = specific conductivity of electrolyte in reciprocal ohms, ν = valency of kation. The quantities on the right-hand side of this equation can be all determined experimentally, so that the value of UC can be found. Suppose now the values of UC are determined for a series of solutions of varying concentrations, and the products U_1C_1/U_nC_n, U_2C_2/U_nC_n calculated. If the values of C_1/C_n, C_2/C_n be determined by measurements of concentration-cells and application of Nernst's formula, then the quotients U_1/U_n, U_2/U_n can be found, and so the variability or constancy of U can be tested. Such in brief is the author's method. The experimental portion of the paper deals with the determination of the quotients C_1/C_n, C_2/C_n, &c., by means of measurements of the E.M.F.'s of concentration-cells. Proceeding in this way it is found that the mobilities of K, H, and Na in solutions of KCl, HCl, and NaCl respectively *increase* considerably with *decreasing* concentration. Furthermore, by assuming complete ionisation in solutions of N/600 concentration, and thereby deducing actual ionic concentrations from the ratios given by the E.M.F. measurements, the author succeeds in verifying the Ostwald-Planck dissociation-formula for dilute solutions of the above-mentioned electrolytes. There is a want of agreement in stronger solutions, but the author ascribes this to the failure of Nernst's formula for solutions which are not sufficiently dilute. F. G. D.

1889. *Isohydric Solutions.* **W. D. Bancroft.** (Journ. Phys. Chem. 4. pp. 274–289, April, 1900.)—The statement of Arrhenius that no change of dissociation occurs on mixing isohydric solutions cannot be upheld except in the case of binary electrolytes, and then only if Ostwald's law of dilution holds good. The more extended theory given in the paper shows that in many cases an increase or decrease of dissociation is to be expected, but these conclusions have not been verified by experiment. T. M. L.

1890. *Ionisation of Dilute Solutions.* **W. C. D. Whetham.** (Roy. Soc., Proc. 66. pp. 192–203, April, 1900 ; Roy. Soc., Phil. Trans. 194. pp. 321–360, 1900.)—The author examined conductivities at 0° C so as to obtain data which could be really compared with measurements of ionisation by the freezing-point method. The distillation of the water and the measurements were carried out in platinum vessels. In measuring the conductivity, alternating currents were used, but a commutator was introduced so as to include a galvanometer in place of a telephone. Results are given for sulphuric acid, barium chloride, potassium chloride, potassium bichromate, copper sulphate, potassium permanganate, and potassium ferricyanide. These results are plotted in the form of curves between the equivalent conductivity and $m^{\frac{1}{3}}$, a number proportional to the average nearness of the molecules, m being the concentration. The ionisation curve at 0° is appreciably different from that at 18°. The curves are generally straight lines, but those referring to sulphuric

acid, potassium permanganate, and potassium bichromate are abnormal in this respect. In the case of sulphuric acid there is a very marked drop in the ionisation at extreme dilution, which is not satisfactorily explained by interaction between the acid and residual impurities in the solvent as the phenomenon is very constant. This explanation may be sufficient, however, to explain the smaller drop observed in the case of potassium permanganate. In the case of these two bodies, the solutions require time to reach a steady conductivity after the first addition of solute to solvent. The curve of potassium bichromate appears to consist of two parts, which may indicate that the ions are different at different concentrations. W. R. C.

1891. *Storage Battery Problems.*—**E. J. Wade.** (Inst. Elect. Engin., Journ. 29. pp. 460–495 ; Discussion pp. 495–521 and 524–530, May, 1900.)—The author puts forward the theory that at the beginning of the discharge of a lead cell the two plates consist of *allotropic* lead and *allotropic* peroxide. On discharge the molecules, still maintaining their complex structure, pass through a long series of true compounds containing SO_4 in gradually increasing proportions. This absorption of SO_4 continues until the internal resistance rises rapidly, indicating the end of the discharge. Charging is practically a reversal of these changes. The author is of opinion that not more than 50 per cent. of the active material can be sulphated, owing to increase of resistance. If that is so, 1 lb. of lead and 1 lb. of peroxide should give 59·25 and 51·25 ampere hours respectively as a maximum. In practice pasted electrodes hardly ever give more than thirty to forty ampere-hours per lb. of active material, and there is a very considerable falling off in the specific output as the discharge rate is increased. To obtain maximum output the porosity must be molecular. Most negative active material has such porosity because it is obtained by reduction, but this is not so in the case of the peroxide. In the latter, substances added to give porosity only separate the particles and cannot give rise to "molecular porosity." Negative active material may have a 50 per cent. porosity (*i.e.*, may hold its own volume of liquid) ; peroxide will not generally have more than a 33 per cent. porosity. Since solid lead requires twenty-four times, and solid peroxide sixteen times, its volume of dilute sulphuric acid (sp. gr. 1·200) for 50 per cent. sulphation (with a fall to 1·150 sp. gr.), negative and positive active material of good quality can only contain $\frac{1}{24}$th and $\frac{1}{32}$nd respectively of the necessary acid for complete discharge. The author traces out the discharge and charge of a cell, and the effect upon it of insufficient diffusion. This diminishes the output and the durability, and reduces the efficiency. Improvement can only be obtained by striving for "molecular porosity," every molecule of the active material being sufficiently exposed to be acted upon.

In the second part of the paper the author deals more particularly with polymerisation. The utility of lead in storage cells is due not only to the insolubility of the active materials but also to its property of forming complex salts. The author mentions a number of complex lead compounds in support of the idea of polymerisation, and gives the steps involved in taking a plate through discharge, reversal and recharge, assuming that it starts as Pb_{12} and ends as $Pb_{12}(O_3)_{12}$. The chain of intermediate compounds containing varying proportions of SO_4 and O easily explains the observed phenomena ; for example, the presence of peroxide on the negative plate towards the end of complete discharge : the formation of this peroxide sets in before the active material is fully sulphated. The author is of opinion that the internal resistance rises rapidly, and the discharge is practically complete, when the active

materials approach a proportional composition of Pb_2SO_4 and $Pb_3O_2SO_4$ respectively. "Sulphating" would be due to a breaking down of the allotropic bodies. This change may account for the gradual loss of capacity in negative electrodes, which is generally accompanied by shrinking. Sulphating is assisted by local action, and therefore takes place more readily during a period of reversal when both lead and lead peroxide are present as well as sulphate.

Discussion.—**W. E. Ayrton** called attention to the loss in capacity which is caused by taking too low a pressure limit for discharge. This may give rise to failure in batteries for automobiles. He was of opinion that the proposed theory did not account for the fact that the discharge curve of a cell which had undergone a period of rest after charging began with a *rise* instead of a fall. The theory also failed to explain why batteries charged at constant potential had a greater capacity than when charged at constant current. **W. Hibbert** was of opinion that the lead and lead peroxide are not in allotropic forms. He had repeated the work of Darrieus, but failed to obtain similar results in support of an allotropic condition. Loss of capacity on standing is explained by the formation of sulphate through simple chemical action, as had been shown by Ayrton and others. Loss of capacity by too complete a discharge is due to almost complete removal of acid from the pores, and consequent change in the reactions; hydrate is then formed with the production of scale. The termination of discharge cannot be determined by rise in resistance through sulphate, otherwise the value of this resistance would be the same at the end of the discharge and the beginning of the charge, but it is found to fall to $\frac{1}{10}$ths at the beginning of the charge. **G. C. Allingham** preferred a simple sulphate theory, the peroxide being reduced to Pb_2O_3, thus accounting for the 50 per cent. sulphation referred to above. **J. Swinburne** was of opinion that a cell can be completely run down to sulphate. Sulphate is reducible if the necessary contact is obtained, or there is a sufficient admixture of a conductor. **A. E. du Pasquier** gave figures relating to plates which had utilised 84 per cent. instead of 50 per cent. of the active material. **W. Boyd** was of opinion that acid impurities may account for the loss of capacity in the negative plates. **E. J. Wade,** in reply, explained that the loss in capacity of negatives to which he referred was that which takes place gradually in the course of years. The reducibility of lead sulphate is probably determined by its solubility. W. R. C.

1892. *Osmotic Theory of the Voltaic Cell.* **M. Couette.** (Journ. de Physique, 9. pp. 200–208, April, and 269–279, May, 1900.)—After having referred to the divergence of views in France and Germany concerning the seat of the various P.D.'s in a Daniell cell, the author proceeds to give a sketch of the modern thermodynamic theory of the voltaic cell. His method of attacking the subject consists in preventing irreversible concentration-changes by providing every liquid concerned with a semi-permeable piston and a water-reservoir, so that every change of concentration yields its quota of (osmotic) work, and in avoiding irreversible Joule heat by employing a conductor of infinitely small capacity to carry electrical charges from one pole to the other, so that the cell is always open, and the average current infinitely small. The external work can now be expressed as the sum of two terms, one relating to the work performed in moving the carrier against the electrical forces, the other to the work done in moving the osmotic piston. As the whole process is isothermal and reversible, the work-differential is a perfect differential, and so according to the time-honoured method a relation

is obtained between its partial differential coefficients, which on integration yields an expression for the E.M.F. of the cell. The result so obtained is applied to the following special cases :—(*a*) Cell with one liquid, solid depolariser, and two electrodes of the same metal (?); (*b*) Daniell type; (*c*) Concentration cell with electrodes of the first sort; (*d*) Concentration cell with electrodes of the second sort. In carrying out the integrations use is made of the van't Hoff osmotic pressure equation. The results obtained are not new, except in the case of (*a*), where the equation is deduced for the case of *incomplete* dissociation.

Having thus considered the thermodynamic theory, the author proceeds to consider the more special features of Nernst's theory, and begins by reproducing Nernst's treatment of liquid cells and diffusion. The subject of solution-pressure and the P.D. at the interface between a metal and a solution of one of its salts is then briefly sketched and the method described whereby the total E.M.F. of concentration and other cells can be calculated by means of the separate P.D.'s. The author acknowledges here the agreement between the total E.M.F.'s so calculated and those observed experimentally, but remarks that this agreement only proves the correctness of the *separate* terms which make up the expression for the total E.M.F.

In the concluding section of his paper, the author considers French work on the subject. The calculations given here are based on (*a*) The thermodynamical theory given in Section 1; (*b*) "Pellat's Law," according to which the P.D. at the junction of a metal and a solution of one of its salts is *zero*. Consequences are deduced which are not in agreement with Nernst's theory. No experimental evidence is given in order to decide the matter. The author's final summing up is that Nernst's theory only agrees with the observed facts when its results are identical with those given by the purely thermodynamical method.

[The *only* basis for this statement that is given by the author is the "Pellat's Law" referred to above. This law is based on a particular interpretation of experimental facts.] F. G. D.

1893. *Gas Concentration-cells with and without Difference of Level, and a new Species of Gravitation-cell.* **E. Bose.** (Phys. Zeitschr. 1. pp. 228–230, Feb. 17, 1900.)—The author considers a gas-cell containing the same gas at each electrode, but at different pressures. There is a difference of height between the levels of the surface (*i.e.*, of the electrolyte) at each electrode, and the difference of gas-pressure is due to this column of electrolyte. The vapour pressure of the electrolyte is neglected. Let p_1 = pressure of gas at lower electrode, p_2 = pressure at higher, h = difference of level, s = sp. gr. of electrolyte, then in the first place, $sh = (p_1 - p_2)$ 13·596. Further let n_1 = number of atoms in molecule of gas, n_2 = number of charges per atom (*i.e.*, valency), R = gas constant, T = absolute temperature, E_1 = potential-difference, or E.M.F. of cell. From the consideration that for every c.c. of gas which disappears at pressure p_1, one c.c. of the electrolyte must fall a height h_1, we obtain by equating gravitational work to electrical energy :—

$$E' = 0{\cdot}634 \,.\, 10^{-5} \frac{T}{n_1 n_2} \frac{sh}{p_1} \text{ volt.}$$

or from above,

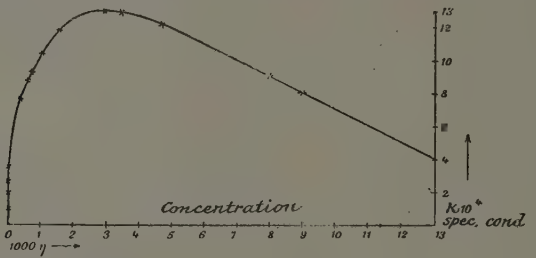
$$E' = 0{\cdot}862 \,.\, 10^{-4} \frac{T}{n_1 n_2} \frac{p_1 - p_2}{p_1} \text{ volt.}$$

Viewed as an ordinary concentration cell, we obtain also :—

$$E_1 = 0{\cdot}862 \,.\, 10^{-4} \frac{T}{n_1 n_2} \log \frac{p_1}{p_2}.$$

The total E.M.F. of the cell is the algebraic sum of these two potential-differences. The author shows also how a purely gravitational cell can be obtained by suitably coupling up a cell of the above description with another which contains the same gas at the same pressures at its electrodes, but has no difference of height between the surfaces of the electrolyte. In an experiment on a cell of the sort described above the author obtained the value 0·0050 volt for the total E.M.F. The calculated value was 0·0051 volt, of which about one-half is due to gravitational energy. F. G. D.

1894. *Conductivity of Ammonia Solutions.* **F. Goldschmidt.** (Phys. Zeitschr. 1. pp. 287–289, March 31, 1900.)—It is only in the most dilute solutions that ammonia obeys Ostwald's dilution laws. The dilution function falls rapidly at higher concentrations. The annexed diagram shows the



specific conductivities at various concentrations (mols. per litre). It shows that there is a maximum conductivity at about 3 or 3·5 normal concentration. The author supposes that the ionic velocity of ammonia varies with the concentration. The retardation is small at first, but eventually its effect masks that of the addition of further ions. E. E. F.

1895. *Model to Illustrate Electrolysis.* **E. Müller.** (Zeitschr. Elektrochem. 6. pp. 589–591, June 14, 1900.)—A wooden model is described, consisting essentially of two rows of wooden blocks displaced in opposite directions at different velocities. The blocks represent ions, and their liberation at the electrodes is shown by their falling out of line. The model also explains the accumulation of the electrolyte, say HCl, at one electrode in the course of electrolysis. E. E. F.

1896. *Limiting E.M.F. in the Electrolysis of Chlorides.* **E. Müller.** (Zeitschr. Elektrochem. 6. pp. 573–578, May 31, and 581–583, June 7, 1900.)—The usually accepted value for the limiting E.M.F. for chlorine ions is 1·31 volts. The author, however, advances reasons for considering this value incorrect. The value is based upon results obtained by two methods of observation.

The first depends upon plotting as a curve the currents passing through a solution of a chloride, with gradually increasing E.M.F. At 1·31 volts, or thereabouts, a sharp upward bend occurs in this curve. This, in the author's opinion, only indicates the commencement of some chemical change in the electrolyte, and he shows by the analogy of an electrolyte containing H_2SO_4 and K_2CO_3 that it is probably due to a depolarising reaction, and not to the liberation of gaseous chlorine.

The second method of observation is to note the potential difference

between two platinum electrodes, the one saturated with hydrogen and the other with chlorine gas, when immersed in normal hydrochloric acid. It is assumed that the voltaic chain is represented by—

$$Pt \mid H_2 \quad n.HCl \quad Pt \mid Cl_2,$$

but the author considers it more probable that the chain is as follows :—

$$Pt \mid H_2 \quad n.HCl \quad Pt \mid HClO.$$

The author's own experiments were therefore directed towards noting the changes in the curves obtained by the first method when E.M.F.'s rising beyond 2·0 volts were used, with (1) n.HCl, (2) n.NaOH and n.NaCl, and (3) n.NaCl and $\frac{n}{100}$ NaOH as electrolytes. The results obtained support his theory, and prove that while at 1·31 volts some chemical change is inaugurated at the anode, a far more important change occurs between 2·2 and 2·4 volts. The author does not specifically state that this is the limiting E.M.F. at which the chlorine ions pass into the molecular form, but he maintains that both Wohlwill and Lorenz, who have published results of their work on this subject, have failed to use in their investigations a sufficiently high potential, and have only explored the range of E.M.F. at which depolarising changes are occurring.

The remainder of the author's paper deals with the various equations which may represent what is occurring at the anode at these lower E.M.F.s. The equation—

$$\bar{O}(++) + \bar{Cl} = \bar{Cl}O,$$

corresponds to the value 1·31 volts, and the author is inclined to believe that this is the depolarising reaction which has been mistaken by other observers for the change represented by

$$\bar{Cl}(+) + \bar{Cl}(+) = Cl_2. \qquad \text{J. B. C. K.}$$

1897. *Electrolysis through Semi-permeable Membranes.* **B. Moritz.** (Zeitschr. Phys. Chem. 33. pp. 513–528, June 1, 1900.)—The systems studied were Kathode | $CuSO_4$ | Membrane | K_4FeCy_6 | Membrane | $CuSO_4$ | Anode, and the corresponding system with zinc in place of copper. In each case the membrane of zinc or copper ferrocyanide was formed on the parchment paper which separates the compartments of the cell ; the kathode membrane gets thinner during the passage of the current and the anode membrane thicker. At the anode membrane, on which all the measurements were made, polarisation occurs, increasing gradually to a maximum of about 0·22 volts with a current density of 0·105, 0·140, or 0·175 milliamperes per sq. cm., in accordance with Wiedeburg's formula (Wied. Ann. 51. 310, 1894)—

$$p = \frac{AP(1 - e^{-xt})}{A - Pe^{-xt}},$$

where A is the E.M.F. of the primary current, P the maximum E.M.F. of polarisation, and x a constant depending on the nature of the cell. If the current density is further increased, a constant maximum E.M.F. of polarisation no longer occurs, and the polarisation increases with the current-density. On gradually increasing the current at intervals of three minutes it was found that the polarisation steadily increased, but in one experiment with a copper ferrocyanide membrane a maximum E.M.F. of polarisation of 1·006 volts was

observed at a current density 7·950, and on further increasing the current density to 19·080 the polarisation decreased to 0·898 ; in the other experiments this maximum was not reached. T. M. L.

1898. *Anodic Changes during Electrolysis of Chlorides.* **F. Foerster** and **H. Sonneborn.** (Zeitschr. Elektrochem. 6. pp. 597–604, June 21, 1900.)—The liberation of oxygen gas at the anode which always accompanies the electrolysis of solutions of the alkali metal chlorides, and increases with the concentration of $C\bar{l}\bar{O}$ ions in the electrolyte, has been ascribed by some investigators to the electrical discharge of these $C\bar{l}\bar{O}$ ions, and by others to the discharge of the $\bar{O}H$ ions present in the electrolyte.

Le Blanc and Haber and Grinberg have, however, shown that the electrolysis of a dilute solution of hydrochloric acid yields free oxygen at the anode, although the conditions preclude the presence of free hypochlorous acid. The authors' aim in the present research has been to clear up this question of the origin of the anodic oxygen. The apparatus used in their experiments is first described, and the methods of analysis used for the determination of the products of electrolysis at the anode are explained. The experiments were so conducted that in each case a neutral and *hypochlorite free* layer of electrolyte separated the anode and kathode divisions of the cell. The evolution of oxygen at the anode could not therefore be attributed to hypochlorite formed by diffusion of sodium or potassium hydrate into the anode division of the cell. The results of a large number of experiments show that portions of the current varying from 0·09 per cent. up to 6·3 per cent. were accounted for by the free oxygen collected at the anode ; the largest volume of oxygen being found with a dilute electrolyte and high E.M.F. The solution surrounding the anode after electrolysis was also examined for chlorate, but the difficulty of estimating its amount correctly in such a solution renders the results somewhat unreliable.

The authors carried out a third set of experiments, using a dilute hydrochloric acid solution as electrolyte. The amount of oxygen found in the anode gas was lower than in the two other series of experiments with neutral chloride solutions, and was also lower than that observed by Haber and Grinberg.

As a result of their investigation the authors state that the presence of oxygen in the gases from the anode, when solutions of neutral chlorides are electrolysed, must be attributed to the hypochlorites or hypochlorous acid present in such solutions as a result of secondary reactions.

They finally discuss the bearing of their experiments and conclusions upon the theories of chlorate production advanced by Wohlwill and by Lorenz and Wehrlin. J. B. C. K.

1899. *Electrolytic Potassium Chlorate.* **A. Brochet.** (Comptes Rendus, 130. pp. 1624–1627, June 11, 1900.)—The author refers to the work of Haber and Grinberg, Wohlwill, Foerster, Jorre, Müller, Lorenz, and Wehrlin, and of Oettel relating to the formation of chlorates in the electrolytic cell. The majority of these investigators have maintained that under certain conditions the formation of chlorate in the electrolytic cell is due to a primary or ionic reaction.

In a previous communication the author has proved that in neutral or slightly alkaline solutions the chlorate is formed from hypochlorite, *i.e.*, that its formation is due to a secondary reaction. In the present communication he

proves that this theory is also true for alkaline solutions. The proof is based upon the use of cobalt oxide in the cell during electrolysis. This oxide decomposes hypochlorites with evolution of oxygen, but has no action upon chlorates. A cell containing an alkaline solution of potassium chloride yielded 48 per cent. of the oxygen at the anode as chlorate upon electrolysis; but when cobalt oxide was added and the experiment repeated under precisely similar conditions, only 2 per cent. of chlorate was obtained. The author therefore concludes that, contrary to the views of Oettel, Haber and Grinberg, Foerster, Jorre, and of Müller, the formation of chlorate in an alkaline solution by electrolysis is *never* due to a primary reaction between OH and Cl ions. Details of the experiment are given. J. B. C. K.

1900. *Electrolysis of Aliphatic Alcohols.* **K. Elbs** and **O. Brunner.** (Zeitschr. Elektrochem. 6. pp. 604–609, June 21, 1900.)—The authors refer to the work of previous investigators in this subject, especially to that of Dony-Hénault. Their own work is supplementary to that of these earlier investigators, and relates to the anodic changes in aqueous solutions of the aliphatic series of alcohols when electrolysed with platinum, platinum black, or lead peroxide anodes and nickel kathodes. The solutions were rendered conducting by the addition of a small amount of sulphuric acid. The cell was constructed in such a manner that the gases from the anode compartment could be collected and analysed. Details are given of the methods used for testing the mixed gases, and also the liquid remaining in the anode compartment after electrolysis. The following alcohols were electrolysed, with the results named :—

Methyl Alcohol.—The products were formic aldehyde, formic acid, carbon dioxide, and carbon monoxide. The first-named was chief product when using metallic platinum as anode, while carbon dioxide increased in volume when platinum black was substituted, and became chief product when lead peroxide was used.

Ethyl Alcohol.—In general the products were the same as with methyl alcohol, but acetic acid was chief product in place of the corresponding aldehyde, and under the best working conditions 80 per cent. of the current could be utilised for this oxidation of the alcohol.

N. Propyl Alcohol.—The production of the aldehyde diminishes as one ascends the series of alcohols, and with *n.* propyl-alcohol, propionic acid becomes chief product with all three forms of anode material. A 90 per cent. current efficiency can easily be attained in this oxidation.

Iso-Amyl-Alcohol.—The corresponding acid, isovalerianic acid, was chief product by the electrolysis of this alcohol. The corresponding aldehyde was present in traces, and only increased in amount when very low current densities were employed. It was found that the lead peroxide anode was also able to effect this oxidation alone, at the normal temperature.

Iso-Propyl-Alcohol.—The products in this case were acetone, acetic acid, formic acid, and carbon dioxide. A 70 per cent. current efficiency in the yield of acetone could be obtained under certain conditions, but this oxidation product was easily subject to further oxidation with production of acetic and formic acids.

An attempt was made to repeat the experiment with an alkali in place of sulphuric acid for imparting conductivity to the solutions, but it was found that condensation products of the aldehydes were formed at the anode.

J. B. C. K.

1901. *Electrolytic Processes for Alkalies.* **J. G. A. Rhodin.** (Soc. Chem. Ind., Journ. 19. pp. 417–419, May, 1900.)—The author deals with his subject historically and subdivides it under two heads, viz., processes involving the use of a diaphragm for keeping the products at the two poles separate and processes employing mercury as a kathode for retaining the sodium as sodium amalgam, from which it can subsequently be recovered as sodium hydrate. It is, however, nearly impossible to make a strong solution of alkali in the former, as the alkaline hydrate, having a lower decomposition value, after a short time is acted upon by the current, in preference to the chloride with the formation of hydrogen mainly at the negative. The Hargreaves & Bird process and the question of lowest voltage at which salt can be decomposed is next discussed. Subsequently the patents dealing with a mercury kathode are given in chronological order and the differences between them explained. Finally, mention is made of the Hulin & Vautin processes for electrolysing alkaline chlorides in the fused state. J. L. F. V.

1902. *Electrolytic Hypochlorite for Bleaching and Disinfecting.* **J. B. C. Kershaw.** (Electrician, 45. pp. 289–291, June 15, 1900.)—An account is here given of the most important processes and apparatus for the production of bleaching solutions from alkaline and magnesium chlorides. Those of Hermite, Stefanow, Kellne , Woolf, Corbin, and Vogelsang are discussed, mention being made of the master patent of C. Watts, No. 13755/1851, which contained the essential features of these methods.

The conditions necessary for the production of bleaching solutions are essentially the following: (1) Insoluble electrodes. (2) No diaphragm. (3) Low temperature of the electrolyte. (4) Rapid circulation from kathode to anode.

Electrolysers for the production of hypochlorites are then described. Hermite's electrolyser consists of a long, shallow, open tank containing two sets of revolving zinc discs as kathodes entirely immersed, the anodes of platinum gauze being placed in between them. The electrolyte is a solution of sodium chloride (magnesium having been abandoned). For bleaching purposes it seems to have been moderately successful in Sweden, but its use for disinfecting after numerous trials has been given up. For a yield of 1 kilo of chlorine in the form of hypochlorite, 10·2 E.H.P. hours are required.

Stefanow's electrolyser is said to be used extensively in South Russia, but no figures are obtainable. It resembles the Hermite cell, and solutions equal to 6 grams. per litre of available chlorine are the result. Lime is used, and probably prevents the reduction of the hypochlorites already formed by the kathodic hydrogen.

Kellner's electrolyser consists of an earthenware cell fitted with electrodes, centrifugal pump, and enamelled receiver with cooling worm. Circulation of the salt solution is thus maintained till the desired strength is reached. Platinum-iridium wires wound round glass plates form the electrodes. A number of places are mentioned where the apparatus is successfully at work. A current of 114 amperes at 112 volts for three hours yielded 5·5 kilos of active chlorine equal to 9·4 E.H.P. hours per kilo of active chlorine.

Woolf's electrolyser has anodes of platinum-iridium and kathodes of zinc. Sea water is being used at Havana; efficiency, 7·5 E.H.P. per kilo of chlorine.

In the Corbin electrolyser the output equals 11·1 E.H.P. hours per kilo of chlorine and in the Vogelsang apparatus 6·6 E.H.P.

The author then proceeds to calculate the power necessary, assuming a

minimum E.M.F. of 2·3 volts for decomposing NaCl in solution, and finds it to be 4·73 E.H.P. hours per kilo of chlorine. A comparative table is then given showing that the efficiency ranges between 42 and 71 per cent.

Comparison is made between the cost of chlorine in the form of bleaching powder at £7 10s. per ton, which is 6·8d., and that of the Kellner electrolyser, which is 7·2d. per kilo of available chlorine.

Actual bleaching tests by means of electrolytic and ordinary methods for calico goods show that the cost for the former method is about one-third of the latter, according to a circular by the Kellner Company.

The author arrives at the conclusion that electrolytic bleaching, *i.e.*, sodium hypochlorite, will be found by actual trial not only an efficient, but also an economical bleaching agent in comparison with the materials hitherto in use. O. J. S.

REFERENCES.

1903. *Critical Temperature of Mixture.* **N. J. van der Lee.** (Zeitschr. Phys. Chem. 33. pp. 622–630, June 1, 1900.)—Paper similar to that referred to in Abstract No. 1444 (1900).

1904. *Electro-chemistry.* **M. Bodenstein.** (Phys. Zeitschr. 1. pp. 272–275, March 17; 283–284, March 24; and 291-295, March 31, 1900.)—These papers contain a synopsis of the different technical chemical processes in which the electric current is used, a short description of each being given. J. B. H.

1905. *Electro-chemistry.* **H. Borns.** (Feilden, 3. pp. 23–33, July, 1900.)—This article gives general information with regard to the present position of the electro-chemical industry throughout the world.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

1906. *Use of Gasoline Gas for Boiler Heating.* **H. Poole.** (Mech. Eng. 5. pp. 786–788, June 2, 1900. Paper read before the American Society of Mechanical Engineers.)—During April, 1898, experiments were made with a view to determine whether suitable gas for boiler firing could be obtained by carburetting air by passing it through liquid gasoline. A special gas apparatus was made in which air was forced by blowers through the gasoline, the carburetting chamber being capable of being heated by steam if necessary to assist the vaporisation. A mixing cylinder was added nearer the boiler, because a small quantity of hydrogen gas, generated in another vessel by the reaction of dilute sulphuric acid on zinc, was, along with air, to be mixed with the gas from the carburetter before ignition. Additional air for combustion was also added in the furnace, but the burners tried were of a crude and more or less unsatisfactory form.

The boiler was a cylindrical multitubular boiler 14 feet long by 3 ft. 6 in. diameter, with 38 flue tubes 3 inches diameter. The heating surface in the boiler was 520 square feet with an additional 111 square feet in a superheater. The general result was that whilst steam could be raised with this fuel, and a very satisfactory distribution of flame could be ensured, the process was too costly. It took 35 gallons of gasoline, costing 10 cents per gallon, to generate 1,000 lbs. of steam at 60 lbs. per square inch pressure. This was equal to an evaporation of 1,211 lbs. of water from and at 212° F., and corresponds to an evaporation of only 34·6 lbs. of water per gallon of gasoline at a cost of about fivepence, or of about 5·3 lbs. of water per lb. of gasoline. The following gives the results of the test.

Summary of Data and Results.

Time of trial	about 2 hours
Grate surface	3 ft. 8 in. by 5 ft. 5 in. or 19·9 sq. ft.
Water heating surface	520 sq. ft.
Superheating surface	111 sq. ft.
Total heating surface	631 sq. ft.
Ratio of water heating to grate surface	26 to 1
Ratio of minimum draught area to grate surface	1 to 12
Steam pressure	60 lbs.
Temperature of air	50° F.
„ „ boiler room	80° F.
„ „ steam	292·5° F.
„ „ waste gases at chimney (estimated)	325° F.
Fuel used	Air gasoline gas
Quantity of oil used (estimated)	35 gallons
Weight of oil used	227·5 lbs.
Calorific value per lb.	20,000 B.T.U.
Total weight of water in boiler	12,500 lbs.
Weight of water evaporated	1,000 lbs.
Feed water used	none.

HEAT BALANCE.

Total heat value of 1 *lb. of oil used,* 20,000 *B.T.U.*

	B.T.U.	Per Cent.
Heat absorbed by boiler	3,483,250	76·5
Loss due to water formed by combustion of the hydrogen	385,100	8·5
Loss due to heat in the chimney gases	236,600	5·0
Loss due to incomplete combustion	—	—
Loss due to absorption, radiation, &c.	445,050	10·0
	4,550,000	100·0

F. J. R.

1907. *Liquid Fuel Apparatus of S.S. Cardium.* (Engineer, 89. p. 534, May 25, 1900.)—A description of Orde's system of spraying liquid fuel. The oil is pumped from the fuel bunker into a settling tank. Thence it is pumped, at a pressure of about 60 lbs. per square inch, through a heating coil in the smoke box. The spraying steam, and air for burning, are also heated. The hot oil, air, and superheated steam are mixed in an injector burner before being sprayed on broken incandescent fire brick covering the fire bars, through which air is also admitted. It is claimed that complete combustion is obtained by this method. J. T. R.

GAS AND OIL ENGINES.

1908. *Riché Gas Producer.* **P. Corbier.** (Génie Civil, 37. pp. 149–151, June 30, 1900.)—Recent improvements are seen at the Paris Exhibition in an installation for producing gas from wood, suitable for driving gas engines and for heating purposes. The generator consists of two cylindrical retorts of cast-iron placed vertically, and heated to a cherry-red by the gases from wood or coal burned in a central furnace surrounded by masonry. The cut wood is fed into the top of the retort, and the charcoal and residue from the distillation falls to the lower part of the retort, kept at a temperature between 850° and 900° C. to decompose the vapours from the wood passed down through it. The apparatus is easily worked and the gas formed is taken through a hydraulic box to the gas holder, and through a sawdust purifier for use in the gas engine.

The value of the charcoal varies with the kind of wood. Moisture in the wood only requires more fuel in the furnace, but does not affect the quality of the gas produced, probably because the water-gas formed is equal in heating value to the wood-gas. Each retort can distil, per hour, 10 to 12 kg. of wood, making 70 to 90 cubic metres of gas of calorific value of 3,000 calories per cubic metre, or nearly three-fifths that of town gas. The composition by volume of Riché wood-gas is CO_2, 20 per cent.; CO, 20 per cent.; C_2H_4, 15 per cent.; and H_2, 45 per cent. The flame is of high temperature owing to the absence of nitrogen. In practice, 1,000 cubic metres of this wood-gas are produced by distilling 140 kg. of wood, and burning 56 kg. of average quality coal or 160 kg. of wood, and the residue is 26 kg. of wood charcoal.

A water float antifluctuator is also described, which on the one hand prevents sudden changes of pressure in the gas supply, due to the suction of the gas engine, and on the other hand acts as an exhaust silencer. W. R.

AUTOMOBILISM.

1909. *Gobron Petrol Motor.* (Automotor Journal, 4. p. 450, June, 1900.)—This motor is of the two-stroke type and is designed to work upon the well-known crank-chamber suction and compression system. The two features of novelty consist of forming the inlet port, from the combustion chamber into the working cylinder, in the piston head so that the charge enters centrally; and of setting the axis of the working cylinder tangentially to the crank shaft so as to reduce the amount of negative work done by the fly-wheel [according to the inventor]. A sectional drawing of this motor is given. A. G. N.

1910. *G. Richard's Car.* (Automotor Journal, 4. pp. 442–444, June, 1900.)—A fully illustrated description of this vehicle. The chief points of interest are the transmission gearing and the motor governor. The car is of the touring four-seated type and is said to be exceptionally strong and rigid. The gearing is of a kind similar to the well-known Panhard gear, but is driven by a belt, from a double cylinder horizontal petrol motor (in front). The pulley wheel upon the shaft driving the speed-gear is fitted with a friction clutch which enables it to be fixed to or freed from that shaft. The various trains of spur wheels are thrown in and out of mesh in the usual manner. The motor governor is mounted upon the half-speed shaft, which operates the exhaust valves, and is fitted inside a metal drum. It is of the centrifugal type, and it acts upon sliding exhaust cams in such a manner that, as the engine speed increases, the one exhaust valve remains closed throughout the cycle of the engine, and then the other exhaust valve is only opened by its cam for two-thirds or one-third of the exhaust stroke of the engine; if the speed still further increases neither exhaust valve is opened. Variably timed electric ignition is fitted to these machines, motors of either 7 or 10 H.P. are fitted according to requirements, and their speed can be varied from 400 to 1,200 r.p.m. by a handle which acts upon the governor. A. G. N.

1911. *Automobile Waggon for Heavy Duty.* **A. Herschmann.** (Mech. Eng. 5. pp. 724–727, May 26, and 779–781, June 2, 1900. Abstract of a paper presented at the Cincinnati meeting of the American Society of Mechanical Engineers, May, 1900.)—The advantages of self-propelled vehicles are speed, small space occupied, and absence of smell. Damage to the roads owing to their weight is less than that caused by horses' hoofs. Good roads are necessary for successful working, but the saving in their cleanliness and hygienic condition compensates for such additional expenditure. Extra safety is insured in consequence of the rapidity with which a motor vehicle can be stopped; a horse can seldom pull up from full speed in less than thirty yards, but a three-ton car can be stopped in eight yards when travelling at eight miles per hour. Powerful brakes are easily provided and the motor also lends itself, when necessary, to a similar purpose. The limited distance which a horse can travel renders the motor waggon superior in an important respect. A steam waggon is superior to its other mechanical competitors because it has a greater radius of action and because the necessary supplies and fuel, &c., can be easily procured; oil waggons are chiefly inferior because of their difficulties of operation. The tendency with steam cars is to make them larger because their proportionate weight of machinery is less. The actual cost of propulsion is much smaller than with animal traction. The best steam cars have been produced in England. The most serious difficulties arise when they are used on rough roads. No form of rubber tyre is satisfactory for waggons

intended to carry a load of over one ton ; steel shields have been tried in combination with rubber, but without success. Steel tyres on stiff wooden wheels have been found to be the best ; they strengthen the wheels, and with dished wheels are indispensable. Well-constructed springs should always be used to lessen the shocks on the wheels. The width of the tyre is a subject of divergence of opinion. For waggons up to a capacity of two tons the total width of tyre should be two inches per gross ton carried, for heavier waggons this width should decrease to one inch per ton. Small driving wheels are generally used because of their extra strength and because of the high speed of the motors ; apart from these considerations larger wheels (than three feet), say four feet, are better because they do not sink in as deeply when they pass over depressions in the road. Any advantages to be derived from front-driving are more than counterbalanced by the awkward position of the machinery which is necessitated ; if all four wheels could be driven in a practical manner it would prove an excellent feature of a waggon. The arrangement of the differential gear on the driving axle, when dished wheels are used, is troublesome ; there is room for improvement in this connection. The provision of two different ratio gear-trains is advisable in the transmission gearing. A suitable boiler must be safe, small, quick-steaming, and economic. A shell boiler is preferable to a tubular type in several respects. Coal and coke are more suitable than oil, as fuel, at the present time. In using a shell boiler it is convenient to fire through the boiler top. Condensers are troublesome on motor waggons owing to leaky pipes and the difficulties in running a condenser. Smoke difficulties have been practically overcome. Compound steam engines are convenient because of the powerful starting moment which can be obtained by admitting high pressure steam into the low-pressure cylinder ; the cylinder ratio should be larger than with stationary practice because the pressure used is higher. Most waggons hitherto made are too light to stand the severe strain of their work. A heavy car is as easy to stop as a light one. At present the steam waggon is the most successful vehicle for the economical transportation of heavy loads. With horse traction the capacity is limited, running expenses are highest, and fixed charges are lowest ; with steam cars the capacity is unlimited, the running expenses are lowest and the fixed charges are highest ; for this reason lightness of construction is less important than many people think. (Drawings are given of a steam-driven waggon manufactured by the Adams Express Co., and of a steam waggon shed ; these are designed by the author.) A. G. N.

1912. *Tourand Automobile.* (Locomotion Automobile, 7. pp. 358–363, June 7, 1900.)—This car is arranged on somewhat similar general lines to the well-known Daimler vehicles. The motor, the carburettor and the speed-changing gear, however, differ in many essential respects. Full particulars of the machine, with clear illustrations, are given. The motor (invented by M. Crozet) consists of two parallel cylinders having a common combustion chamber, and each actuating a separate crank-shaft. One inlet and one exhaust valve only are used. The crank-shafts are parallel to each other, and are geared together by spur gearing. Each crank is fitted with a balance weight, and the two cranks, which revolve in opposite directions, are so adjusted relatively to one another that the two pistons always reciprocate in unison. Both crank-shafts carry flywheels at one end, but power is taken direct from one shaft only. The motor works on the four-stroke cycle, and develops 7½ B.H.P. The carburettor is of the "spray" type, but does not require any constant level float device. The air passage through the mixing

chamber is partly obstructed by a grooved and inverted cone, which is fixed to a needle valve, normally closing the petrol feed to the chamber; when the air is drawn by the piston suction past this cone, it causes the cone and the valve to lift and to thus admit petrol into the air passage. The air then sprays the petrol upon the surface of the cone and thus forms an explosive mixture with it. The petrol feed is regulated by means of a set screw which fixes the degree to which the needle valve can be lifted. The speed gearing is of the well-known spur and bevel wheel type, but the various trains of wheels always remain in mesh with each other, and are called into play alternately, as desired, by means of friction clutches. The total weight of these vehicles is about 15 cwt.; they are fitted with supply tanks of sufficient size for running about 60 miles without attention. A. G. N.

1913. *Pennington's Military Automobile.* (Scientific American, 82. p. 408, June 30, 1900.)—A four-wheeled machine designed for the use of light artillery to carry a couple of Maxim or Colt guns into action rapidly. The framework consists of two longitudinal 3-inch steel tubes, which carry the rear axle and the front steering-wheel heads, and are tied together by cross braces. The motor consists of two water-jacketed, steel tube cylinders, 5¼ in. in diam. by 12 in. stroke; these are placed horizontally, and are connected to a crank shaft, having overhung cranks at either end and a heavy central flywheel between its main bearings. Power is transmitted from either of two chain wheels, on either side of the flywheel, to the rear axle; either of these two different speed-gears can be put into operation by means of friction clutches fitted to the chain wheels on that axle. The machinery is placed so as to give a low centre of gravity, and is protected by a belt of armour. The water tank serves as a wind shield in front. Supplies of water and petrol for running 150 to 200 miles are provided for. Tube and electric ignition are both fitted. The power of the motor is stated to be nearly 40 H.P., and a speed of over 60 miles an hour is said to have been attained on a half-mile track. The wheels are 22 in. diam., and are equipped with 5 in. pneumatic tyres. This machine weighs 1,500 lbs., and will accommodate eight people, a steersman in front, a driver behind, and three passengers on each side. Two photographs of this car are reproduced. A. G. N.

1914. *Mercié Two-speed Gear.* (Automotor Journal, 4. p. 441, June, 1900.)—A mechanism designed for use on light voiturettes or motor-cycles. An arrangement of spur-wheels, on two parallel axes, and of clutches whereby a sleeve mounted about the driving axles may be caused to revolve at either of two speeds, relatively to the axle, or may be disconnected from it entirely. Drawings showing its application to a tricycle and a section of the mechanism are given. A. G. N.

REFERENCES.

1915. *American Corliss Engines for Electric Traction.* **C. Day.** (Engineer, 89. pp. 532–533, May 25, and 558–559, June 1, 1900.)—A description and some illustrations of American practice.

1916. *Boiler Testing.* (Mech. Eng. 5. pp. 833–835, June 16; 871–873, June 23; and 909–910, June 30, 1900.)—Articles dealing mainly with the methods of determining the calorific value of the coal and the composition of the flue gases. Full particulars are given of the methods of using the Thomson and the Carpenter fuel calorimeters.

GENERAL ELECTRICAL ENGINEERING.

1917. *Commelin and Viau's Storage Cells.* **J. Blondin.** (Écl. Électr. 23. pp. 452–456, June 23, 1900.)—This is an illustrated article giving general particulars of the construction of two types of cell. Both contain a cadmium sulphate electrolyte from which cadmium is deposited on charge upon a kathode of lead or carbon, and in the one type the anode is simply a slight modification of the usual grid filled with lead peroxide. The other cell is a partial gas battery, for the anodes consist of tubes of carbon, and the oxygen given off from their surfaces on charge is collected under pressure in suitable receptacles, recombining to form water on discharge. No data are given as to the performance of this cell, but some curves of fall of potential on slow discharge rates and figures deduced from these as to output for weight are furnished for the other type. E. J. W.

1918. *Evershed's Frictionless Motor-Meter.* **S. Evershed.** (Inst. Elect. Engin., Journ. 29. pp. 743–781; Discussion, pp. 781–794, July, 1900.)—In this meter, the vertical axle carrying the armature is provided with a step bearing having a jewel cup at its lower end, and with a magnetic suspension at its upper end, whereby nearly the whole of the weight of the axle and parts mounted thereon is removed from the step bearing. This magnetic suspension comprises a bar magnet arranged in line with the axle, so that the induction density remains constant during rotation of the axle; and the pole-piece of the magnet is separated from the upper end of the axle by a plate of non-magnetic material, so that, in the event of the axle being jolted upward, it cannot remain adhering to the magnet. The commutator segments for the armature are fine iridio-platinum wires supported at one end in an ivory collet, and entirely free at the other end, where they impinge and roll on the peripheries of wheels which replace the brushes usually employed. The counting train is driven from the armature without contact by the following device, viz.:—On the upper part of the axle is a solenoidal electromagnet having two coils in series with parts of the drum-winding of the armature, so that the currents therein reverse simultaneously twice each revolution. This electromagnet acts on an annular soft iron armature encirling it, and this armature is mounted at the end of an oscillating lever actuating the counting train through a pawl and ratchet-wheel. By this means, the lever makes a double stroke every revolution of the armature.

This meter has given extremely good results, having a range of at least 1 to 50. The paper includes an account of earlier magnetic suspension devices; appendices giving methods of calculating the armature torque, brake torque, and frictional resistance; and also tabulated tests of some meters.

In the *Discussion*, **W. M. Mordey** described Stanley's magnetic suspension and showed a model. This device consists of a pair of feather-edged discs at each end of the axle, each disc being encircled by a narrow annular pole-piece. The pole-pieces of one pair are connected to the N-poles of *e.g.* two permanent magnets, while the pole-pieces of the other pair are connected

to the S-poles of these magnets, so that there is a magnetic flux along the shaft which causes the shaft to float in the air. Extensions of the shaft pass through guide holes at each end. C. K. F.

1919. *High-voltage Switches and Fuses.* **Zetter.** (Soc. Int. Élect., Bull. 17. pp. 132–137, March, 1900.)—The best length of break for 220-volt fuses is 2·5 cm. for 2 amperes, 3 cm. for 5 amperes, 3·5 cm. for 15 amperes, and 4 cm. for 30 amperes. E. H. C.-H.

1920. *Acrograph.* **N. S. Amstutz.** (Elect. World and Engineer, 35. pp. 247–250, February 17, 1900.)—A beautiful instrument for translating the variations of relief of a carbon print into corresponding variations in the depth to which a cutter, on a kind of screw-cutting lathe, cuts lines in a metal plate. The result is the formation of a delicate reproduction in the form of an engraved plate, suitable for printing from, without injury to the carbon print. A. D.

1921. *Testing Electric Railway Systems.* (Street Rly. Journ. 16. May, 1900. Supplemental Chart.)—In this chart, 11 tests are given, viz., for bonds; current flow in water-pipes; drop on ground return circuits; local earth resistance between pipe and rails; relative conductivity of rail and pipe returns; location of grounds or leaks; line conductivity; equalisation of compound-wound generators; and equalisation of motors. C. K. F.

1922. *Transmission Dynamometer.* **W. E. Goldsborough.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 219–227, April, 1900.)—The author states that the principles upon which the success of his dynamometer depends have been already used in several other instruments; it is in the adaptation of these principles that the chief novelty consists. It consists roughly of a shaft made in two parts, one of which is turned down so that its end exactly fits a concentric hole bored in the other part. Each section of the shaft is provided with a spiral grip thread turned to fit a spiral spring. The ends of the spiral spring are fastened with jaw collars, which not only hold the end turns of the spring very securely, but also prevent them from springing out when the direction of rotation is such as to tend to unwind the spring. The angular displacement of the spring can be measured to within the fifth part of a degree by an ingenious electrical device. Two brushes are held by two brush-holders which are mounted on the dynamometer bearings, and are fitted with 90° graduated scales. The brushes are carried on insulated brush-rods, and are connected with one another through primary batteries and a telephone. This circuit is only completed when the brushes make contact at the same instant with two metal pins carried on wheels fastened to the two portions of the shaft. When the brush-holders are in the proper position a click will be heard in the telephone at every revolution of the dynamometer shaft. If ordinary conditions of constant load are maintained, the author states that the relative motion between the contact points will be zero, even with the lightest spring he uses, and hence the frequency of the click is constant. With his dynamometer he determines the full load torque within one-tenth of 1 per cent.

The author gives the results of a very complete and interesting test he made on a three-phase motor. He joined this motor by means of his transmission dynamometer, to what practically was a direct-current series dynamo. By this means he obtained great stability at all loads. This was owing to the

fact that the torque of the direct-current machine increased very nearly as the square of its armature speed, and therefore very much faster than the torque of the induction motor. The torque can thus be measured at all speeds and not merely for speeds below the speed of maximum torque.

Diagrams are given of the dynamometers, and full details of the shaft and spiral spring clutch jaws are also given. A very simple method of calibrating the dynamometer is described. The whole operation of taking out one spring substituting another, and calibrating it need not take more than ten minutes. After adjustment it may be placed in the hands of inexperienced experimenters, as there is nothing to get out of order. A. R.

1923. *Apparatus for Determining the Relative Crank Positions of Two Engines in Motion.* **P. v. Kowaleff.** (Elektrotechn. Zeitschr. 21. pp. 502–503, June 21, 1900.)—It has been stated that certain types of alternators will run in parallel satisfactorily only if the cranks of the engines driving them are in corresponding positions. This is probably true where large equalising currents are necessary to keep the machines in step. But when the equalising currents are small, it would probably be best to run the machines so that steam admission does not take place simultaneously in all the engines, but consecutively. Such an arrangement would have the double advantage of reducing speed fluctuations and exposing the steam pipes to the least amount of shock. In any case it is interesting to have some means of ascertaining the relative crank positions of two engines which are in motion. For this purpose the author has devised the apparatus shown in Figs. 1 and 2. A suitably constructed voltmeter V (Fig. 2) is joined in series with a source of E.M.F. Q (either continuous or alternating), and two two-way switches, u_1 and u_2,

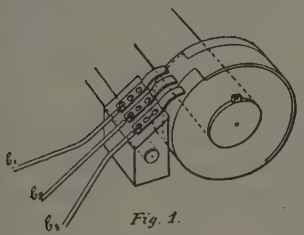


Fig. 1.

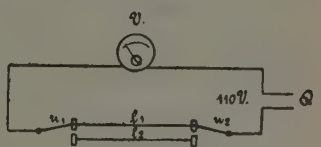


Fig. 2.

mounted on the shafts of the two machines respectively. The moving part of the voltmeter has a large moment of inertia, and its motion is strongly damped. The contacts of the two-way switches are connected by means of two wires, l_1 and l_2. The construction of the two-way switches is shown in Fig. 1. A sleeve of insulating material mounted on the crank-shaft, carries a specially-shaped ring of metal, the central portion of which forms a continuous ring, while the side portions consist of semicircles. Three brushes, placed as shown, serve to bring about the periodic change of connections. It is obvious that when the switches, u_1 and u_2 work co-phasally, the voltmeter reading will be at its maximum, while, if there is opposition of phase, the reading will be zero. Intermediate phase differences give intermediate readings. For the purpose of calibrating the arrangement, the two switches are mounted side by side on the same shaft, with an arrangement for displacing the one relatively to the other. The shaft is then rotated approximately at the speed of the engine, and the readings corresponding to various angular displacements of the two switches are noted. A. H.

1924. *Heating of Underground Cables.* **K. Wilkens.** (Elektrotechn. Zeitschr. 21. pp. 413–416, May 24, 1900.)—In continuation of the work of Kennelly, the author investigates the problem of finding the rise in temperature in a given conductor and a given dielectric, when surrounded by media of different thermal capacities and different thermal conductivities, with a view to determining the maximum safe electric current, as regards temperature, for any specified cable. The thermal equation gives an expression for the rise in temperature between two points in the thermal path normal to the conductor, in terms of the distance between the two points, the mean dimensions of the path, the quantity of heat evolved in the conductor, and the thermal constants of the material. The quantity of heat per second, corresponding to a given current in the same conductor, is then expressed in watts; and, making certain assumptions, equations are found—(1) For the distance between the two points, as above, for a given difference of temperature between them; and (2) for the thermal resistance (*Wärmeleitungswiderstand*) of the thermal circuit. Experiments are described in which observations are made of the rise of temperature in particular cases, corresponding to various currents in the conductor of a cable. An iron tube, filled with oil, was heated electrically by an enclosed spiral of wire. This tube was buried in a horizontal position in the earth. Temperature observations were made by means of a thermometer in a vertical oil-tube, communicating with the main tube. During the experiments the vertical tube was surrounded with snow. Similar tests were made in which the tubes were submerged in wax, sand, water, and air respectively. The author does not say how the difficulties of convection currents in the oil tubes were overcome, there is consequently some doubt as to how the results are to be interpreted. His relative figures for thermal resistance, as measured in a particular case after twenty-four hours' steady current, are: wax, 3·29; water, 4·98; sand, 5·23; air, 11·8. The results are tabulated, and curves are drawn, showing the radii of the heat zones and the temperature differences under various conditions of current and environment. R. A.

1925. *Heating of Underground Cables.* **R. Apt.** (Elektrotechn. Zeitschr. 21. pp. 613–617, July 26, 1900.)—In calculating the maximum current which an underground cable may safely carry, it has been the custom to adopt the same formula as for overhead cables, namely—

$$C = k_1 d^{3/2}$$

where k_1 is a constant, d the diameter of the cable, and C the current. It is evident that the conditions are quite different in the two cases; in the one there is cooling by radiation, and in the other by conduction. In order to apply the laws of heat conduction to this case, the conditions which the author assumes are that the cable lies along the axis of a cylinder of earth of radius equal to the depth of the cable below the surface, and also that the outside of this cylinder is kept at a constant temperature. He thus obtains the formula—

$$T = \frac{m C^2}{\Delta}$$

where T is the excess of temperature of the cable above that of the surface, C the current in the cable, Δ the section of the copper, and m a constant. This gives, when T is constant, $C = k_2 \sqrt{\Delta}$, where k_2 is another constant, and equal to $\sqrt{T/m}$.

A number of experiments carried out at the cable works of the Allgemeine Electricitäts Gesellschaft gave results which satisfy the above formula.

The cable to be experimented on was buried at a depth of 0·5 m. in a large tank (6·8 m. × 1·5 m. × 1·5 m.) filled with damp sand. The cable was doubled back on itself several times, so that when the current was sent through it, the effect was similar to that of several cables laid side by side, and all carrying the same current. The temperature of the cable was obtained by measuring its resistance.

The results show that the rise of temperature, when the steady state is reached, is proportional to the square of the current, and inversely proportional to the section of copper in the cable. In the equation—

$$T = \frac{m C^2}{\Delta}$$

the constant $m = 0{\cdot}016$ for values of Δ from 25 up to 1,000 mm.², and for values of T up to 50° C. Taking different constant values for T, and calculating the value of the constant $k_2 = \sqrt{T/m}$, we find that it is approximately numerically equal to T + 15, so that if the rise of temperature in the cable is never to exceed 25°, the maximum current which it may carry is given by—

$$C = 40\sqrt{\Delta}$$

C being measured in amperes and Δ in (mm.²). This makes a simple formula for practical purposes, and one easily remembered. J. B. H.

1926. *Cheap Mains for Electricity Supply.* **C. M. Harris.** (Elect. Engin. 25. pp. 880–881 ; Discussion, p. 881, June 22, 1900. Paper read before the Municipal Electrical Association.)—The paper deals with the lighting of small towns, in which the cost of underground mains is the chief consideration. At Bray the mains are paper-insulated, lead-covered, and laid in puddled clay, and after eight years are as good as new. The system of jointing is described, and a table of tests on the cables is given. Pitch is recommended for filling joint boxes. The cost of laying the cables as above was 1s. per yard, and of making a joint 9s. 6d. It is suggested that low pressure cables may be of bare copper, laid on insulators in troughs filled up with pitch ; such cables have withstood 1,000 volts for twelve months without deteriorating at Bray. In the discussion it was stated that the pitch did not attack the lead covering of the cables. A. H. A.

1927. *Standardising Electrical Machinery.* **P. Sellon.** (Inst. Elect. Engin., Journ. 29. pp. 291–303; Discussion, pp. 304–344, April, 1900.)—The absence of standardisation in England is due to the purchasers being unconnected with manufacturing interests, the engineer acting for the purchaser being frequently tempted to specify "showy" divergencies in minute detail instead of simply stating the ends required by the buyer. With repetition manufacture, the makers will guarantee results. Competition between manufacturers will be sufficient to prevent stagnation. Details of design must not be standardised, but only ends or performance. Standards should be determined by organised effort rather than by the present costly process of trial and error, and should be done by the I.E.E. *Discussion :* **R. E. Crompton** did not think that absence of standardisation had done much harm up to the present. The small variety of pressures shown in the author's table proves that consulting engineers have not varied very much. Small motors of one-third and one-sixth H.P. are already being standardised, and this will occur increasingly

with larger sizes suited to tools taking a definite amount of power. **J. Slater Lewis** remarked that establishment charges on a machine would fall 60 per cent. if only one type were made. The charges are higher on electrical than they are on any other machinery in this country. Our shops should be standardised. **J. S. Raworth** remarked that pressure and periodicity are analogous to gauge in a railway. In this, the governing factor, consulting engineers have come much nearer Mr. Sellon's standard than he imagines. The standardisation of details is far more important in effecting economy than standardisation of pressure or periodicity, and in this matter small alterations made by a draughtsman in his work are an example of the simple way in which a standard can be departed from. **M. Robinson** was of opinion that if electrical firms would attack the problem with courage, they would attain their wish. In the case of one order of a single engine for 1,200 H.P., Willans & Robinson at once expended a much larger sum than the price of the engine upon standard jigs and templates, but eventually before the first engine was out of the place eighteen others were on order, and the templates were paid for many times over. **R. Hammond** remarked that the periodicities of 83, 84, 87, 80, and 81 arose from his standard of 10,000 complete alternations per minute with slight fluctuations of engine speed. The disadvantage of a manufacturer as compared with a consultant, is that the former sees so very much of his own productions. The function of a consultant is not to aim at brilliancy, but to see that the contractor gives what he has undertaken to give. **W. B. Esson** remarked that there is neither on the Continent nor in England any great agreement as to standards between the manufactures of different firms, though there is greater agreement in particular firms. The fact is, no one firm in this country has enough of any one class of machines to keep them going. No consulting engineer that he had ever known would refuse to accept a good thing from stock rather than draw up a specification for it. There are great difficulties in specifying things without to some extent defining the means by which they are to be obtained, because in providing the means the guarantee required as to the fulfilment of the ends for a long period is obtained. We are beginning at the wrong end by fixing a standard for frequency. In America, where ropes and belts are used, uniform frequency only means a change of pulley. Similarly turbines are easily altered to suit the standard dynamos insisted on. Consulting engineers have never dogmatised about frequency ; it is only the manufacturers who have done this. There is no analogy between frequency and railway gauge, and frequency is the one factor which ought not to be fixed. **L. Andrews** was of opinion that if details are not insisted on, makers must take greater responsibility. The Hastings Company is an example of how taking the advice of a company, and not of a consultant, led to anything but a standard supply station. **S. A. Russell** was of opinion that units cannot be standardised because of the various speeds of standard engines. Belt-driven plant need not be standardised. It is rather a disadvantage if all makers have exactly the same sizes. In adopting American voltages, &c., for traction, we have handicapped our own makers and our lighting stations. The rating of machines should certainly be fixed, and say a 50-kw. machine shall be one that will give 50 kilowatts continuously for a certain number of hours. **L. Birks** gave tables of periodicities at various stations, showing that we are rapidly deciding on 50 periods. M. O'G.

1928. *Causes of Heating in Metal Bearings.* **R. Job.** (Mech. Eng. 5. pp. 818-819, June 9, 1900. Abstract of an article in the American Engineer and

Railroad Journal.)—The author draws attention to the fact that it is well known that physical condition and structure have a great influence upon the wear of the metal in a bearing. Generally great care is taken to ensure the correct chemical composition and little attention is paid to the conditions under which the finished shape of the metal is produced in the foundry.

The old copper-tin alloy of seven to one has been found to be inferior as a bearing metal, and a copper-lead-tin composition introduced. The efficiency is found to increase with the proportion of lead present, though this cannot exceed 15 per cent. in practice.

Tests of a large number of bearings which had run hot and had been removed from the carriages of the Philadelphia and Reading railway are referred to. The causes of excessive heating indicated by an examination of the results of these tests may be summarised as follows: (1) Segregation of the metals. (2) Coarse crystalline structure. (3) Dross or oxidation products and an excessive amount of enclosed gas in the metal.

Want of proper lubrication may, of course, be also mentioned, but this cause accounted for but a small percentage of the bearings examined.

Segregation is found to be due in many cases to an attempt to alloy the metals in improper proportions, notably in the case of copper-tin-lead compositions, in which it has been sought to introduce an excessive proportion of lead. To some extent segregation can be prevented by the use of a cold mould, but then the ductility is decreased, with the result of rapid wear in service.

The coarsely crystalline structure is found to be due to the presence of antimony in the alloy, but more frequently to the practice of rapid pouring at high temperatures. It is also caused by the presence in excess of deoxydising agents. The effects of crystallisation upon the bearing are twofold. In the first place, increased local heating results owing to the varying degrees of hardness and heating capacity of the constituents, and secondly, the ductility and tensile strength are materially decreased.

The presence of dross is simply a proof of carelessness in the foundry. Excess of enclosed gas may be due to insufficiency of deoxydising agents or to pouring at too low a temperature.

Increase of strength and ductility is found in all cases to be synonymous with better wear. An instance is cited of two bearings practically of the same composition, one set giving on test a tensile strength of 16,500 lbs. per square inch and elongation of 6 per cent., and the other giving 24,000 lbs. per square inch tensile strength and 13 per cent. elongation, the difference being attributable to the porosity of one and homogeneity of the other. It was found that the first-named set had worn 35 per cent. more in the same time than the second set. E. C. S.

1929. *Power required for Heavy Machine Tools.* (Engineer, 89. pp. 304–306, March 23, 1900.)—With all tools, except grinding machines, the power required at the Atlas Works, Sheffield, was obtained by direct experiment with a portable motor. In the case of grinding machines, these experiments could only show the power that caused the belt to slip, not the maximum that could be usefully employed on the shaft of the grinding disc. Experiment shows that it is certainly not less than 40 H.P., and possibly much more. Planing machines are the least well adapted to electric driving owing to the momentum to be absorbed and reinitiated in a contrary direction. It was not found feasible to run the separate motors driving the planing machines in parallel. Until this can be done it would seem better to run not less than

three machines from one motor. The small amount of oil used by roller bearings is much in their favour, but a more lengthened experience of them is desirable. A double-screw planing machine 14 ft. 8 in. between the standards, cutting speed 10½ feet per minute, took 25½ H.P. at the start and 18 during the stroke. A 3-inch spindle double radial-arm drilling machine, drilling two holes ⅞ inches diameter, took 1½ H.P. A side planing or ripping machine (pair of saddles driven by screw), holding 1 inch ploughing tools, one cutting and one returning, speed 9 ft. 9 in. per minute, took on a heavy cut at a maximum of 4½ H.P. A very large slotting machine, cutting tool 1¼ inch wide, feed $\frac{1}{80}$ inch on very tough material, took on the return stroke against the weight of the tool arm a momentary 15 H.P. and 10½ maximum during stroke. Recording ammeter readings are reproduced.

M. O'G.

1930. *Electric Power in Factories.* **G. H. Bowden.** (Elect. Engin. 25. pp. 591–593, April 27, and 633–637, May 4, 1900. Paper read before the Glasgow University Engineering Society.)—It is economical to provide cables for extension, whereas this cannot be done with steam pipes with economy. A complete transition to electric driving can be made in any factory without stopping the work. The results obtained in various important works are reviewed. The capital expenditure at Dorman and Long's was £8,000 and the saving at the rate of £4,000 a year. At Furness Withy the output has been doubled, yet the working cost is less than before. Every machine in a shipyard can be electrically driven except the steam hammers. The following table is given of the power absorbed by shipyard tools :—

	E.H.P.
Double punch, running light	2·0
Punching both ends 1 in. hole, ⅞ in. plate, 28 punches per minute at each end	5·0
Punch and shear, running light	2·0
Punching hole as above, and shearing ⅞ in. plate, 5½ in. cut, 28 strokes per minute	6·5
Large plate-bending rolls, running light	5·5
Rolling plate $\frac{5}{16}$ in. thick, 4 ft. 4 in. wide, and 16 ft. 6 in. long, endways on (4 ft. 4 in.)	6·9
Sideways on (16 ft. 6 in.)	12·2
Plate $\frac{1}{10}$ in. by 4 ft. 8½ in. by 21 ft. long, sideways on	19·3
Same rolls lifting and lowering top roll : Lifting	8·5
Lowering	7·0
Forcing $\frac{1}{16}$ in. plate down	10·0
Forge fan, for 24 fires	10·5
Angle squeezer, running light	0·8
Squeezing	2·5
Wood-working machinery. Small plane	0·8
Tenoning machine	0·8
Band saw	1·5
Cross-cut saw	2·5
Small circular saw cutting 6 in. pitch-pine hand-fed	6·4
Circular saw 48 in. sawing 18 in. teak, 6 ft. 6 in. per minute	24·0
Sawing 4½ ft. teak, 25 ft. per minute	17·7
Countersinking machine. Actual power taken in countersinking	·5

	E.H.P.
Riveting machine, running light	1·6
Riveting	3·0
Wall planer, taking $\frac{3}{8}$ in. cut, cast iron	5·0
Radial drill, drilling $1\frac{1}{4}$ in. hole, cast iron	1·59
Plate planing machine, running light	0·6
Reversing light	1·8
Cutting 1 in. by 14 ft. plate	3·1
Stern frame, boring, cutting	1·75
Shafting lathe 18 in. centre, running light	0·5
One tool cutting $\frac{1}{16}$th in. square cut	1·8
Two " " "	2·5
Lathe 9 in. centre, $\frac{3}{16}$th in. cut	0·6
Angle-cutting machine, running light	1·6
Cutting angle 6 in. by $3\frac{1}{2}$ in. by $\frac{1}{2}$ in.	3·5
Winch, lifting 28 cwt. single purchase, 50 ft. per minute	6·5
Ending machine, running light	1·9
Cutting girder 18 in. by 7 in.	4 to 4·8
Cold saw, running light 24 in. saw	2·0
Cutting 4 in. by 4 in. angle	4 to 4·5
Air compressor, 10 in. by 14 in. cylinder, 50 lbs. pressure	15 to 23·5
Portable drill, when drilling 1 in. hole	1.5
Hydraulic pumps, three pumps, $3\frac{3}{4}$ in. diameter ; $4\frac{3}{4}$ in. stroke, 60 strokes per minute ; pressure, 870 lbs.	38·0
Joiners' shop motor, normal load	14·8 to 22
Machines being driven from this motor : One 20 in. plane, one circular saw 24 in., one 30 in. planing and sand-paper machine	
Electric winch, running light	1·2
Lifting 24 cwt. 16 ft. per minute	5·6

Drawings are given of an enclosed motor with flexible shaft, an electric centrifugal pump, drill, and a travelling crane. The first cost of a polyphase system is greater than that of a continuous current. Difficulties also come in where the motor has to be constantly reversed or the speed varied. Greater margin must be allowed in the powers, so that the cost of application is nearly double that of continuous current. M. O'G.

REFERENCES.

1931. *Berrenberg's Air-pump for Lamp Manufacture.* (Elektrotechn. Zeitschr. 21. pp. 214–219, March 15, 1900.)—This article gives a full description of the Berrenberg mechanical air-pump (see 1900, Abstract No. 418), illustrated by a photograph and a number of detail drawings. C. K. F.

1932. *Starting Resistance for Continuous-Current Motors.* **R. Krause.** (Elektrotechn. Zeitschr. 21. pp. 328–329, April 26, 1900.)—A method of calculating the resistances so that the motor shall start evenly and without sparking at the commutator, the section of the wire being also arranged to carry the varying currents without overheating. E. K. S.

1933. *Wiring.* **C. E. Knox.** (Amer. Electn. 11. pp. 479–481, and p. 529, 1899 ; 12. pp. 42–45, Jan., 91–92, Feb., and 142–143, March, 1900.)—Description of Outlet boxes (pp. 479–481), Cut-out cabinets (p. 529), Panel boards (pp. 42–45), and Switchboard design (pp. 91–92 and 142–143).

GENERATORS, MOTORS, AND TRANSFORMERS.

1934. *Helios Co's. Three-phase and Single-phase Alternator at the Paris Exhibition.* (Elektrotechn. Zeitschr. 21. 499–502, June 21, 1900.)—This machine forms one of the four large generating sets in the German section of the electricity building. It is capable of giving either 2,000 kw. on a single-phase circuit, or 1,200 kw. on a single phase, and 1,500 kw. on a three-phase circuit, at 50 periods, when running at 70 revs. per minute, number of poles, 84. A line drawing and four photos are given showing the construction of the machinery, also particulars of the energy stored in the flywheel. E. K. S.

1935. *Magnetic Leakage in Inductor Alternators.* **C. F. Guilbert.** (Ind. Élect. 9. pp. 255–258, June 25, 1900.)—The effect of magnetic leakage is more important in inductor alternators than with ordinary alternators, as the magnetic flux in the armature of the former does not reverse in direction, but merely oscillates between a maximum and minimum value both of the same sign. If we assume that when the flux is a maximum the iron circuit of two inductor poles is bounded on the inside by three sides of a square of length t, the other side being moved parallel to itself through a distance d equal to the air gap, and if we suppose that the breadth of the poles, which are rectangular in section, be also t, and that the wheel is so large that we can neglect its curvature, then

$$\eta = \frac{\text{lost flux}}{\text{useful flux}}$$

$$= \frac{d}{t}\left[\frac{4}{\pi}\left\{\log_e\left(\frac{\pi t}{2d}+1\right)+\frac{t}{\mu d}\right\}+\left(1+\frac{t}{\mu d}\right)\frac{t}{t+d}\right]$$

With the inductions used in practice, μ the permeability is about 80. The author gives the following practical example. For an Oerlikon inductor alternator of 800 kilowatts—

$$t = 23{\cdot}5,\ d = 0{\cdot}5 \text{ and } \mu = 90.$$

Substituting these values in the formula, we get

$$\eta = \frac{0{\cdot}5}{23{\cdot}5}\left\{1{\cdot}27(4{\cdot}3+0{\cdot}52)+1{\cdot}52\frac{23{\cdot}5}{24}\right\}$$

$$= 0{\cdot}16$$

The true value of η found experimentally was 0·15. The author's approximate formula always gives results slightly in excess of the true values of the leakage. He, however, in this paper gives accurate formulæ, taking into account the curvature of the inductor wheel, &c. He states that Kapp's formula,

$$\eta = 1{\cdot}7\frac{d}{t}\log_e\frac{t}{2d}$$

always gives results much too small. For example, using Kapp's formula to find η in the above case, we find $\eta = 0{\cdot}114$. A. R.

1936. *Synchroniser for Rotary Converters.* **F. W. Springer.** (Elect. World and Engineer, 35. pp. 944–945, June 23, 1900.)—The author describes a device invented by J. Pearson, of Minneapolis, by means of which rotary converters can be speeded up and put in circuit without any special skill being required on the part of the operator. The ordinary method is to run the converter as a motor from the direct current side, one switch of the three-phase circuit being closed. When the synchronising lamps across one of the other three-phase switches show that it is running in synchronism with the generators, then the remaining two three-phase switches are closed. The author states that, unless this be very carefully done, disastrous results may ensue. It is found advisable in practice to cut off the direct current from the converter at the instant the connection with the alternating circuit is completed, in order to avoid the risk of the conflicting direct and alternating current effects throwing it out of step. Pearson's device does this automatically. It is in use in all the power houses of the Twin City Rapid Transit Company, Minneapolis, and has been in daily use for over a year to put a 750 kw. rotary in circuit. A. R.

1937. *Alternating Current Induction Motors (especially Heyland Motors).* **A. C. Eborall.** (Inst. Elect. Engin., Journ. 29. pp. 799–886; Discussion, pp. 836–856, July, 1900.)—This is a comprehensive paper on the design of induction motors, in which the author gives particular attention to the starting devices of monophase motors, special stress being laid upon the Heyland method.

The Heyland method of starting monophase motors consists in winding the starting stator-coil with comparatively few turns in such a way as to produce large magnetic leakage, while the running-coil has many turns with as small magnetic leakage as possible. The rotor has a tri-phase star winding connected to three slip rings, by means of which resistance may be inserted till full speed is attained. The large leakage of the starting-coil causes a lag between the current therein and the potential difference between its terminals. A difference of phase thus exists between the currents in the running and starting-coils, and a rotating magnetic field results.

The Heyland motors standardised for circuits of forty, fifty, and sixty cycles are designed in three ways, as follows: (*a*) To start without load. Under these circumstances the starting-current does not exceed four-fifths of the full-load working-current. (*b*) To start with two-thirds the full-load torque. Under these circumstances the starting-current does not exceed 1½ times the full-load working-current. (*c*) To start with full-load torque. Under these circumstances the starting-current does not exceed twice the full-load working-current.

Methods of winding are given by which the speed of the motor may be altered to half or quarter the maximum speed. In the discussion the want of a good frequency-changer was emphasised. [See also Abstract No. 348 (1900).] W. G. R.

1938. *Theory of Single-phase Motor.* **F. Eichberg.** (Elektrotechn. Zeitschr. 21. pp. 484–487, June 14, 1900.)—In order to explain the action of a single-phase motor, the device of substituting two oppositely rotating fields for the simple alternating field has been frequently employed. Although this substitution is perfectly legitimate so long as the rotor is at rest, it ceases to hold good when rotation takes place, and in the neighbourhood of the speed of synchronism the motor is known to behave as

if there were only one rotating field. Hence, in his recent paper on this subject, Steinmetz (Elektrotechn. Zeitschr. 1899, Heft 25 and 26) has abandoned this device, and has deduced the equations of the single-phase motor by assuming a cross-field whose intensity is proportional to the rotor speed. In reality, the cross-field is not simply proportional to, but is a complicated function of, the speed. The author develops a simple and elegant theory of the single-phase motor by assuming the single-phase winding split up into two equal parts, and each part connected in series with one-half of an imaginary winding producing a cross-field, the two halves of this latter winding being assumed to convey currents in opposite directions, so as to produce no resultant magnetic effect. [This device has already received notice in Abstract No. 753 (1899).] Each half of the actual single-phase winding, together with one-half of the imaginary winding producing the cross-field, constitutes a complete polyphase winding; but the two polyphase windings give rise to oppositely rotating fields. These two windings are assumed to be connected in series across the mains, and the distribution of P.D. is determined by the same laws as those governing the distribution of P.D. between two transformers connected in series. When rotation takes place, the effective impedance of the polyphase winding producing the field in the direction of rotation is increased, while that of the other winding is decreased. Making use of these considerations, the author explains in detail the working of a single-phase motor. The paper is illustrated by a number of diagrams. A. H.

1939. *Testing Induction Motors.* **M. Breslauer.** (Elektrotechn. Zeitschr. 21. pp. 469–474; Discussion pp. 474–475, June 7, and p. 516, June 21, 1900. Paper read before the Elektrotechnischer Verein, March 27, 1900.)—After briefly explaining the induction motor diagram first given by Heyland in 1896, and recently corrected by him so as to eliminate the errors contained in the original diagram, the author applies the corrected diagram to deduce a number of important relations connecting the various quantities which occur in the study of induction motors. The corrected diagram is shown in Fig. 1, in which A B = i_m = magnetising current (*i.e.*, current taken at speed of synchronism, neglecting losses); A C = i_s = short-circuit current (*i.e.*, current taken by short-circuited rotor when at rest); A D = i_1 = primary current; E D = i_2 = secondary current; A E = magnetising current corresponding to the primary current A D. If i_w and i_o stand for the load and wattless components respectively of i_1, $\tau = \frac{i_m}{i_s}$ for the leakage factor, and cos ϕ for the power-factor, then

$$\tau = \frac{i_m (i_o - i_m)}{i_w^2 + i_o (i_o - i_m)}$$

$$\cos \phi = \sqrt{\frac{(i_m - \tau i_o)\ (i_o - i_m)}{i_m \left\{ i_o (1 + \tau) - i_m \right\}}}$$

$$i_2 = \sqrt{\frac{1}{\tau\ (1 - \tau)}} \cdot \sqrt{i_m (i_o - i_m)}$$

$$i_w = \frac{1 - \tau}{2\tau} i_m$$

The most interesting deductions from these equations are: (1) The greatest overload which the motor is capable of standing is directly propor-

tional to i_m, and since i_m may be varied by altering the number of turns, the point of maximum overload may be controlled by this means; (2) the maximum power-factor is independent of i_m, and depends solely on the leakage factor r. The diagram, Fig. 1, is based on the suppositions of (a) pure sine waves of E.M.F., current and induction; (b) proportionality between the exciting current and magnetic induction; (c) absence of all losses in motor. The author next considers how the diagram must be modified in order to render it applicable to ordinary conditions of working. As regards (a), we know that in other alternating-current problems this supposition leads to results which are sufficiently accurate for practical purposes; (b) is practically correct for the vast majority of induction motors within the working limits. As regards (c), we have to consider: (α) the heat-loss in the primary winding; (β) the hysteresis and eddy-current losses in the primary core; (γ) the heat-loss in the secondary winding; (δ) the bearing and air-friction losses. The losses (α) and (β) might, so far as the diagram is concerned, be supposed to take place outside the motor, and might be represented by a simple resistance connected in series with the motor. The drop occasioned

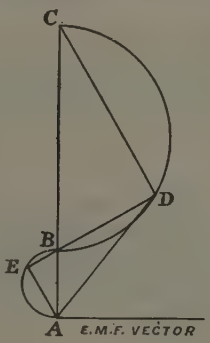


FIG. 1.

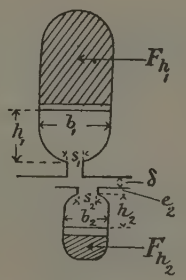


FIG. 2.

by this imaginary resistance would then be taken into account before constructing the diagram. With regard to (γ) and (δ), these may be regarded as an additional load on the motor-pulley. Due allowance being made for the losses, the author proposes the following method of testing induction motors. The motor running light, two curves are determined, connecting the primary P.D. with (1) the magnetising current i_m (this will, as a rule, give a straight line up to the working limit), and (2) the power absorbed by the motor. The rotor is next rigidly clamped and short-circuited through an ammeter, and two further curves are obtained, connecting the primary P.D. with (3) the short-circuit current and (4) the power taken by the motor. Finally, the resistance of the primary is measured. From the data so obtained the behaviour of the motor may be completely determined *without the necessity of any brake tests.* By producing the curve (2) backwards the frictional loss may be separated from the hysteresis and eddy-current losses. The Heyland diagram and the equations deducible therefrom may then be used for calculating the leakage factor, and for constructing curves connecting the load on the motor with efficiency, power-factor and slip.

The author has carefully tested the method in practice, and gives curves showing that the results of brake tests closely agree with the curves deduced by the above method. He next considers the effect of the air-gap and length of polar arc on the value of τ, and arrives at the conclusion that in order to make τ as small as possible, it is desirable to make the motor of large diameter and relatively narrow width; actual measurements of τ appear to point to the fact that the inactive portions of the windings contribute considerably towards magnetic leakage.

In the discussion, **Görges** pointed out that the value of τ depends very largely on the number of slots, and decreases as this number is increased. **Niethammer** contributed the following formula for the primary leakage-field L_1, which he has found to give results closely agreeing with those of actual measurements :—

$$L_1 = K \frac{i_1 Z_1 l}{p q_1} \left\{ \int \frac{F_{k1}\, dh_1}{F_1 b_1} + \frac{e_1}{s_1} + \frac{\delta}{s_1 + 1{\cdot}68} + \frac{1}{\frac{28}{\tau_x} + \frac{s_2 q_2}{e_2 q_1}} + \frac{1}{\frac{28}{\tau_x} + \frac{q_2}{q_1 \int \frac{F_{k2}\, dh_2}{F_2 b_2}}} \right\}$$

where the meanings of most of the symbols are given by Fig. 2. K is a coefficient whose value ranges from 1 to 1·1; Z_1 is the total number of primary conductors; l the length of the motor; $2p$ the number of poles; q the number of slots per pole per phase; F_1 the entire slot area; τ_x the length of the crown of a tooth. The secondary leakage-field is obtained by interchanging the suffixes 1 and 2. A. H.

1940. *Eddy Current Losses in Transformers.* **F. Townsend.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 233–243, April, 1900.)—Experimental results are quoted to show that the eddy-current loss in a transformer may be written in the form $kB^{1{\cdot}6}f^2$, where k is a constant, B the maximum induction density in the core, and f the frequency. If this were true it follows that the total core loss W would be given by the equation—

$$W = B^{1{\cdot}6}(k_1 f + k_2 f^2)$$

where the first term represents the hysteresis loss and the second term the eddy-current loss. The ratio of these two losses would also be equal to $\frac{k_1}{k_2 f}$ and would be independent of the magnetisation. The author analyses some experimental results obtained by W. Peukert, and published in the *Elektrotechnische Zeitschrift* of September 21, 1899 [see Abstract No. 204 (1900)], on iron losses in a transformer, and concludes that the agreement between these results and results calculated on the above hypothesis, are as close as the experiments warrant. A. R.

1941. *Excitation of a Two-phase Rotary Converter at Various Loads.* **E. Wilson.** (Electrician 45. p. 512, July 27, 1900.)—The author quotes experiments of Parshall and Hobart on a three-phase rotary converter, in which they found that the excitation of the converter at full load was about 15 per cent. greater than at no load. He made a similar experiment on a two-phase generator, and found that the excitation was practically constant at all loads. The converter was connected to the two-phase generator by four short conductors, and the excitations of the two machines were so adjusted that the volts across the slip-rings of the generator were nearly

constant at all loads, and at the same time the power-factor of the converter circuit was a maximum. The following are some of the experimental results :—

Revs. per min.	Generator.		Watts delivered.	Power Factor of Converter.	Direct Current.		Exciting Current.	
	Volts per phase.	Amperes per phase.			Volts.	Watts.	Generator.	Converter.
812	82·2	4·23	350·8	0·998	115·2	0	3·00	3·20
815	81·7	30·96	2520	0·99	113·7	4298	3·29	3·19
813	82·1	56·5	4613	0·99	113·5	8240	3·84	3·14

The exciting current of the converter was thus about 2 per cent. less at full load than at no load. A. R.

REFERENCES.

1942. *Dynamo Electric Machinery.* **C. F. Guilbert.** (Écl. Électr. 22. pp. 166–171, Feb. 3, 250–256, Feb. 17, and 449–456, March 24, 1900.)—Recent patented improvements, chiefly in connection with transformers (pp. 166–171), motors and dynamos.

1943. *Weight of Dynamos.* **E. Rosenberg.** (Zeitschr. Elektrotechn., Wien, 18. pp. 165–167, April 1, 173–178, April 8, and 197–201, April 22, 1900. Paper read before the Elektrotechnischen Verein, Jan. 3, 1900.)—An analysis of the various conditions which give minimum weights of copper and iron, for a given output, in the various types of continuous-current dynamos. The paper is mainly mathematical, but some interesting curves are given. E. K. S.

1944. *Rotary Converters.* **A. Moens.** (Assoc. Ing. Él. Liège, Bull. 11. pp. 110–136, April 20, 1900.)—The writings of Steinmetz, Kapp, Thompson, Parshall, and others on the subject of rotatory converters, are reviewed. Interesting notes are given on the subjects of "hunting," frequency, regulation of voltages, armature reaction, &c., and there is a short bibliography at the end of the paper. E. K. S.

1945. *Effect of Line on Working of Synchronous Motors.* **F. Eichberg.** (Zeitschr. Elektrotechn., Wien, 18. pp. 183–184, April 8, 1900.)—A brief abstract of a paper on the above subject. A. H.

ELECTRICAL DISTRIBUTION, TRACTION, AND LIGHTING.

ELECTRICAL DISTRIBUTION.

1946. *Mutual Inductance of Three-phase Circuits.* **A. J. Bowie, Jun.** (Elect. World and Engineer, 35. pp. 939–944, June 23, 1900.)—A very complete discussion of the problem of the mutual induction between the six wires in two overhead three-phase systems of mains is given. The author first of all discusses the magnitude of the effects produced by mutual induction, and then indicates various methods of spiralling the wires, by which these effects can be made negligible, or even altogether eliminated. For example, if the mains forming each circuit be connected to the insulators on the poles in such a way that the mains of each system form a spiral, but the pitch of one spiral is three times that of the other, then the mutual induction will be zero. This is entirely independent of any balance of the loads. The author points out that the ordinary method of making each three-phase system into a spiral, one right-handed and the other left-handed, does not eliminate mutual induction, which produces an unsymmetrical effect on the voltage triangle. In this case, if we interchange two of the wires in one circuit the effect is made symmetrical. In the author's opinion, the more we can avoid the necessity of spiralling the wires the better and simpler will be the system. Hence he gives several solutions in which, although mutual induction has not been altogether avoided, yet spiralling is reduced to a minimum. [See also Abstract No. 928 (1900.)] A. R.

1947. *Limitations of Long-distance Power Transmission.* **W. E. Goldsborough.** (Elect. Rev. N.Y. 36. p. 391, April 18, 1900.)—This article deals with the various factors governing the economy of long-distance lines with extra high-pressure, and the difficulties which are encountered in such work; for example, surface leakage, leakage between conductors when pressures of over 60,000 volts are used, and charging current. The author deals with the question rather fully, and arrives at the conclusion that power can be transmitted to a distance of 500 miles from the generating station with financially good results. E. D. P.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

1948. *Prague Electricity Works.* **E. Kolben.** (Elektrotechn. Zeitschr. 21. pp. 520–528, June 28, 1900.)—This is the first three-phase alternate current central station from which current is supplied from the same 'bus bars for tramways, for power, and for lighting. Current has to be carried to some parts of the town which are nearly five miles distant from the generating station, and for arc lamps, for public lighting, and for tramways continuous current at 600 volts has to be supplied. The general principle upon which the plant is designed is that of a central generating station with substations in which rotary converters are erected. Current is generated at the central station at 3,000 volts pressure, three-phase alternating. Thence it is taken through high-pressure primary circuits to various points where the voltage is reduced by transformers to 123 volts for domestic lighting. A portion of the

high-pressure current goes to rotary converter substations and is converted into continuous current at 500 to 600 volts. Continuous current at this pressure is also generated at the central station for feeding the tramway conductors near the station.

The feed-water for the boilers is taken direct from the Moldan and passes through suitable filtering apparatus capable of cleansing between 9,000 and 10,000 gallons per hour, which capacity can be doubled by enlarging the filter. Thirty-two boilers are installed, each having about 2,300 square feet of heating surface. The boilers are divided into groups of eight, each group having its own chimney, which is 220 feet high and 9 feet 9 inches internal diameter at the top. Each boiler is provided with a superheater, which—it is stated—brings up the temperature of the steam in the main steampipe to between 300° and 340° C. (572° to 640° F.). The boilers work at about 180 lbs., and, presumably, natural draught only is used. Mechanical stokers are provided, and the coal is brought to them by means of conveyers, worked by electricity, capable of moving half a ton in nine seconds.

The engine-house is designed for the reception of five three-phase alternating units of about 1,000 H.P. each and five of about 2,000 H.P. each, besides some smaller continuous current units. The large engines are triple expansion of a somewhat special type.

The method of driving the exciter is novel. The armature of the alternator is mounted direct upon the main shaft of the engine, and the exciter is driven by a toothed wheel, also fixed upon the engine shaft, and pinion geared 4 to 1. The flywheel armature is weighted so as to admit of a coefficient of unsteadiness of $\frac{1}{240}$. Diagrams shown in the original paper indicate the successful achievement of this. Illustrations are given of the larger units and of the rotary converters, and diagrams of the switchboard arrangements at the central station and substations, showing how the accumulator batteries are employed in the ordinary course of operating the plant. The chief point of interest is the adoption of the same periodicity for lighting as well as for power. E. C. S.

1949. *Electricity Works at La Praz* (*Savoy*). **A. Laponche.** (Génie Civil, 37. pp. 128–131, June 23, 1900.)—This is one of the four factories of the French Electro-metallurgical Company, and is devoted to the production of aluminium, pure and in the form of alloys, calcium carbide, &c. It is situated on the left bank of the river Arc, near the Mont Cenis railway, and power is taken from the river by two steel conduits, 2 metres and 2·4 metres in diameter, 1,200 and 1,000 metres long, and with falls of 33 and 72 metres. The plant has a total capacity of 12,500 H.P., and consists for the most part of Thury dynamos (3,000 amperes, 130 volts) driven by Girard turbines. There are also various other dynamos of voltages ranging from 120 down to 40, two being unipolar 40-volt machines of 350 H.P. each ; and two alternators of 800 H.P. and 350 H.P. The high-pressure hydraulic conduit transmits 10,000 H.P., the velocity of the water being 2·75 metres per second. The thickness of the steel of which it is made varies from 5 mm. at the intake to 15 mm. at the turbines. It crosses the river in the form of an arch of 50 metres span, without additional support. Some data are given as to the stresses calculated for this arch when full of water. The plant commenced working in January, 1898. W. H. E.

1950. *Dublin Electric Tramways.* (Elect. Rev. 46. pp. 658–663, April 20, 703–707, April 27, and 745–747, May 4, 1900.)—*System :* Overhead trolley, fed

by continuous current, except on the Dalkey line, which is by three-phase transmission. The *boiler-room* contains 12 Babcock and Wilcox boilers, each having 2,530 square feet heating surface; 160 lbs. working pressure. The feed-water is heated by two groups of Green's economisers in each flue, each group having 192 tubes (9 ft. × $4\frac{5}{16}$ in.). Coal is stored in overhead bunkers of 1,200 tons capacity, and is fired by Vicar's mechanical stokers, to which it is delivered through shoots. Hunt (New York) handling and conveying apparatus transports the coal from the quay to the bunkers. The *engine-room* contains five Allis cross compound vertical engines, having cylinders 20 in. and 40 in. diameter, 42 in. stroke, indicating 800 H.P. at 90 r.p.m. Fly-ball governors control the cut-off by Reynolds' Corliss trip valves on both cylinders. The guaranteed consumption at 630 B.H.P. is 12·7 lbs. steam per I.H.P. Each engine drives directly a 550-kw. G.E. 10-pole continuous current generator, giving 550 volts. The three-phase transmission in the Ringsend power station will consist of one 500-kw. generator coupled to a similar engine, and two rotary converters, each of 250 kw. output. *Feeders* of the lead-covered paper-insulated type are drawn into cement-lined sheet-iron pipes. The feeders vary in section from 0·75 to 0·2 square inch; they are divided into half-mile sections by disconnecting boxes. Distributors of from 0·3 to 0·15 square inch are of similar description, as are the return feeders, one 3,490 yards long, 2·25 square inch section consisting of three cables in parallel, and three from 2,253 to 2,536 yards long, 1·076 square inch section. The return feeders are boosted to the extent of 30 volts by three boosters of 15 kw., and one of 24 kw. capacity. The *track* is equipped on the overhead trolley system: 31 ft. iron poles, built in three sections, carry, by means of bracket arms and span wires, trolley wires of No. 0 B. and S. copper, having a breaking stress of 4,500 lbs., divided into sections of $\frac{1}{2}$-mile. The double track at present completed amounts to $46\frac{1}{2}$ miles, while the outlying portions will bring the total up to $50\frac{1}{2}$ miles. The rails are of girder type, 92 lbs. per yard. The joints are bonded with two 000 Crown bonds and one plastic bond. The foundation of the track is a concrete bed 6 inches thick. The track is paved with granite setts grouted with coal tar and creosote. The motor cars are fitted with Peckham trucks and G.E.–58 motors. They are double-decked and have a capacity of 58 passengers. *Drawings:* Plan and elevation of power station and a map of Dublin. J. T. R.

1951. *Norwich Electric Tramways.* (Electrician, 45. pp. 122–127, May 18, and 167–170, May 25, 1900.)—*System:* Overhead trolley. The *boiler-room* contains four Babcock-Wilcox boilers, each rated at 300 nominal H.P. and having a heating surface of 3,240 square feet; working pressure 160 lbs. The feed-water is heated by a Green's economiser. The firing is effected by Bennis mechanical stokers, to which coal is carried by Bennis conveyers. The *engine-room* contains four Browett-Lindley tandem compound 320 H.P. engines running at 200 r.p.m., capable of giving 500 H.P.; cylinders 16 in. and 26 in. diameter, 17 in. stroke. Each engine drives directly a Westinghouse multipolar railway generator developing 200 kw. at 550 volts, over-compounded for feeder drop. There is also a 15-kw. Westinghouse direct coupled dynamo for the works. The *track* is equipped on the overhead trolley system. Separate forward and return trolley wires are carried on poles by means of double brackets, single brackets, or span wires, to suit the streets, while in very narrow streets rosettes are employed. The rails are of girder type, 3 ft. 6 in. gauge, $65\frac{1}{2}$ lbs. per yard, cast-welded by the Falk process. There are forty motor cars fitted with Peckham trucks, Westing-

house motors, and controllers. There are ten trailers. Both motor cars and trailers are of the double-deck type. *Drawings:* Map, scale plan of generating station, photos of works and plant, section of track, elevation of wheel-grinder, truck, rails, and plans of special work. J. T. R.

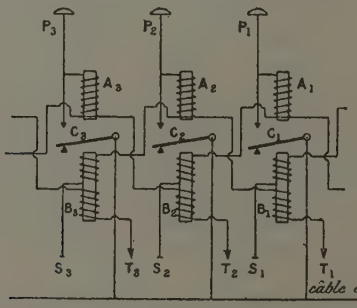
1952. *Lexington and Boston Electric Railway.* (Street Rly. Journ. 16. pp. 415–423, June, 1900.)—This road is designed to obtain part of the traffic between Boston and Lowell, a distance of thirty miles, as well as to connect the various towns along its main line, and to bid for the large amount of excursion business which is attracted by the historical interest of the points through which it passes. The *boiler-room* contains at present two 250 H.P. Caball horizontal water-tube boilers with room for four more. A railroad track runs through the boiler-room and connects with the electric line in front of the car house. Coal is stored in a 350 ton bin, over which the railroad cars can run and dump their contents without the services of a conveyer. An unusual number of heaters are included. In addition to the reheating receivers between the high and low pressure cylinders of the engines, the exhaust passes through a primary heater on its way to independent Canovery 750 H.P. jet condensers. The feed water, after passing through the primary heater, has its temperature further raised by a second heater taking the exhaust steam of the auxiliaries. The *engine-room* contains two 325 kw. General Electric generators of the usual type driven at 100 r.p.m. by horizontal cross compound Corliss engines by the Slater Engine Co., having special gridiron valves for the steam, and horizontal rolling valves of the Corliss type under the cylinders for the exhaust. A sectional drawing is given showing the valve gear, and also a drawing of the 16 feet diameter flywheel. Current is supplied from the power house by one 500,000 circular mil and one 350,000 circular mil cable going north with 4/0 returns; and two 250,000 circular mil cables going south with 4/0 returns. The trolley wires are 2/0. The line is single track with a length of twenty miles laid on chesnut ties, of steam railroad section, 7 feet long, laid 2 feet between centres. In the most popular districts a 95 lb. 9 in. girder rail is used, made by the Pennsylvania Steel Co. Almost the entire right of way is alongside the public highways. In order to attract long-distance traffic the cars are unusually large and handsome. They are 45 feet long, with ten windows, and seating accommodation for forty passengers. The motorman has a separate compartment, so that passengers may use both platforms for exit and entrance without interfering with his duties. Each car is fitted with four G.E.–67 motors, the type recently developed by the General Electric Co. to take the place of the G.E.–1,000. The improvements in this motor are: the field-poles are laminated and the armature core has ventilating spaces; the commutator is larger and longer and insulated with thinner mica to prevent sparking; the number of commutator segments has been increased to 111, but the number of slots is reduced to 37. Each car has two trolleys, one for use for running in each direction. E. K. S.

ELECTRIC TRACTION AND AUTOMOBILISM.

1953. *Willard's Sectional Third-Rail System.* (Street Rly. Journ. 16. pp. 330–331, April, 1900.)—A disused section of the Brooklyn Heights Ry. Co.'s system, a quarter of a mile in length, has been fitted up with this system for demonstration purposes and has been satisfactorily worked during the past winter. The system employs mechanical and not electrical means for cutting

the sections of third rail in and out of circuit. The third rail is of T-iron, about 17 lbs. per yard, carried on brackets and creosoted blocks every few yards, and having its top about 10 inches above the track rails. This rail is laid in 50-feet lengths with a 1½ to 2 inch gap between them. At the centre of each length is a section box containing a single throw switch with copper and carbon contacts, arranged to be closed by the movement of the third rail in either direction. Normally the switch is held off by springs, and it requires a pull of 300 or 400 lbs. on the third rail to operate it. This pull is given by the contact shoe on the car, the shoe consisting of two magnet poles separated by a brass distance piece. When the car leaves a section the springs release the switch without sparking, because the circuit through the next section is already closed. To start up on a dead section a special grip is provided on the car for sliding the third rail. E. H. C.-H.

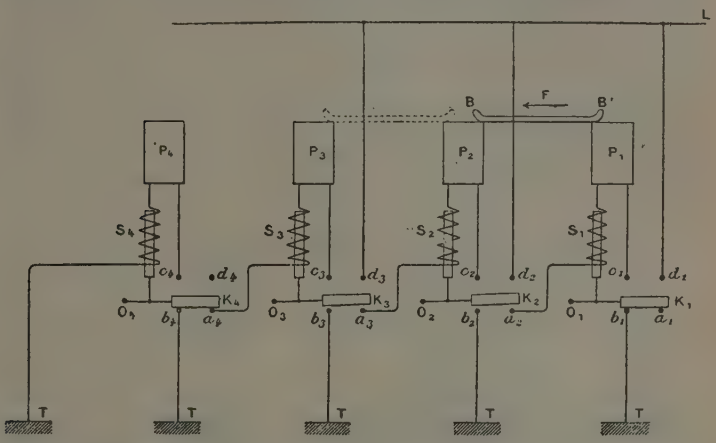
1954. *Paul's Surface Contact System.* **P. Heina.** (Écl. Électr. 23. pp. 53–57, April 14, 1900.)—This system has been installed by Schuckert on one of the Munich tram-lines, and has successfully operated for more than a year. It provides contact studs at intervals of about 4 metres (on straight lines), these plates P_1, P_2, P_3... being connected to controlling switches grouped in chambers under the road or pavement. The operation of the system is evident from the diagram of connections, where C_1, C_2... are armatures connected to



the feeder and brought into, or out of, contact with their corresponding studs P_1, P_2... by the magnets A_1, A_2... and B_1, B_2. The two windings on the magnets are for motion in opposite directions, the points T_1, T_2... and S_1, S_2 being respectively earthed and insulated or *vice versâ*, according as the car is moving from right to left or left to right. The earthing of the required points is performed by one switch for each group, this switch being operated automatically by magnets. Elaborate precautions are taken to prevent the possibility of more than two studs being alive at the same time. E. H. C.-H.

1955. *Vedovelli's Mixed Trolley and Surface-contact System.* **X. Gosselin.** (Soc. Int. Elect., Bull. 17. pp. 138–149, March, 1900.)—Æsthetic and other reasons forbade the trolley in certain sections of the Bois de Boulogne line, and a mixed system was therefore used. No halt is necessary to change from trolley to surface contact, because for a short distance at junctions both are installed, and the bow trolley avoids the difficulty experienced in putting a wheel trolley on to the wire. A diagram of connections is here reproduced. Directly the contact bar B touches the plates P_3, a shunt current traverses

the bobbin S_3, and goes to the rail through a_4 and b_4, which are joined by the armature K_4 pivotted at O_4. S_3 is thus magnetised and draws up K_3 from a_3, b_3, on to d_3, c_3, thus connecting plate P_3 direct to the main. In this way the main current is never broken at the armatures. Where two directions of motion on the same rails are required, either two independent sets of



plates must be used or a switch must be provided to reverse the connections of the solenoids. Plates are spaced at about three meter intervals, and the distributing switches are arranged in boxes holding ten, placed by the side of the track or under the footpath. If one plate fails to make contact, the one behind will remain excited until a trailing chain on the car earths the live plate and so blows the fuse and brings the car to rest. E. H. C.-H.

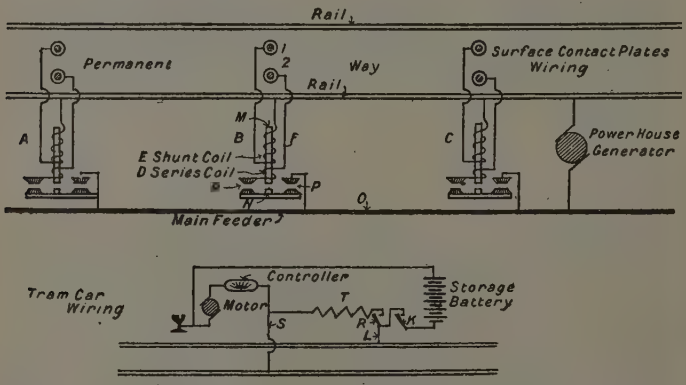
1956. *A Simplified Conduit for Tramways.* **C. Devenyns.** (Soc. Belge Élect., Bull. 17. pp. 113–127, March, 1900.)—The proposed conduit consists of a vitrified casing running along the track and having its upper surface level with the street. The main conductor is slung on insulators inside this casing and consists of a copper strip with a soft iron strip attached to its upper surface. At intervals there are soft iron plugs in the cover of the box, and at these positions there are steel contact brushes attached to the soft iron strip. The picking-up device is a series of magnets with brushes, which slide lightly over the vitrified surface of the casing until they come over the soft iron plugs, when they attract the main conductor, thereby closing the magnetic circuit and ensuring good contact. The main current is thus taken through the iron of the pick-up magnets.

The author proposes to overcome leakage by electrolysis, the products giving insulation ; but the description is not clear. E. H. C.-H.

1957. *High Pressure Three-phase Current for Electric Traction.* **W. Reichel.** (Elektrotechn. Zeitschr. 21. pp. 453–461, June 7, 1900.)—An article describing experiments made since 1898 by Siemens and Halske for the purpose of studying polyphase traction, the current being collected from the trolley wires at 10,000 volts and reduced on the locomotive to a low voltage for supply to the three-phase motors. It was found that with suitable sliding contacts current could be collected at so high a speed as thirty-seven

miles an hour—about twenty-five miles an hour is the limit with the ordinary underrunning trolley. On the trial line the three-trolley wires were suspended one below the other on poles at the side of the track, current being taken off by lateral sliding contacts. Tests were made at 750, 2,000, and 10,000 volts, and it was actually found that the sliding contacts worked best at the highest pressure. Hinged contact bars which rested on the upper side of the trolley wires were given up, as not being suitable. There are eleven illustrations, including a diagram, showing the controller connections and the step-down transformers carried on the locomotive. E. K. S.

1958. *Westinghouse Surface Contact System.* (Engineer, 89. pp. 430–431, April 27, 1900.)—The essential elements of this system are (1) electromagnetic switches enclosed in moisture-proof iron cases and each permanently connected to the positive main, (2) cast iron contact plates, in pairs, placed between the rails, each pair being electrically connected to a separate switch,



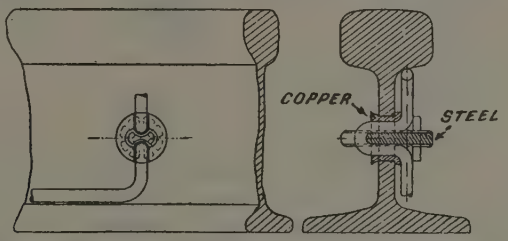
(3) metal contact shoes or bars, two of which are suspended from the underframe of each car, (4) a small storage battery on each car. The diagram of connections reproduced explains the operation of the system. The magnetic switches can be made up complete at the factory, with their pairs of contact plates carried by insulators on the switch-box casting. E. H. C.-H.

1959. *Accidents to Overhead Tramway Equipment.* **J. V. Drescher.** (Zeitschr. Elektrotechn., Wien, 18. pp. 289–293, June 10, 1900.)—An article going into the causes of breakages in overhead line material. Most of these are caused by undue wear on the trolley wire at certain points, as for instance where the wire is bent round at a splicing ear. Where possible a springy suspension is recommended. Where a tramway passes under a low bridge the trolley pole comes down to an almost horizontal position and the upward pressure is considerable. In such cases the author recommends running the trolley wires through wooden troughs having the lower sides open for the passage of the trolley wheels. E. K. S.

1960. *Electrolysis by Earth Returns.* **J. Teichmüller.** (Elektrotechn. Zeitschr. 21. pp. 436–438, May 31, 1900.)—The author reviews in detail the various methods which have from time to time been proposed and used for overcoming electrolytic troubles due to stray currents. The most satisfactory

method of dealing with this problem is that devised almost simultaneously by Kapp and Rasch, and which consists in introducing boosters into the return feeder circuits so as to maintain the feeding-points in the track at zero potential. The author gives a full description of the arrangements used at Bristol, where the method was first applied with signal success. More recently it has been used at Schöneberg, near Berlin, and in Dublin. A. H.

1961. *New Tramway Bond.* **Hecker.** (Elektrotechn. Zeitschr. 21. pp. 403–404, May 17, 1900.)—In referring to a recent paper by J. S. Edström [see Abstract No. 1612 (1900)] the author describes a bond used on the Zurich tramways. The construction is as indicated in the figure herewith, and the advantages claimed are: (*a*) Large conducting areas between the bond and the rail.



The contact area of the wire is about 400 sq. mm. and the area between the copper thimble and the rail 880 sq. mm. (*b*) By driving out the steel plug or key the bond may be used over again. (*c*) The connecting piece consists of only a plain copper wire. (*d*) The arrangement is quickly fitted, there being no soldering or amalgam to trouble with. E. K. S.

1962. *Accumulator Trials (Paris).* **A. Bainville.** (Électricien, 19. pp. 167–169, March 17, and 211–214, April 7, 1900.)—An objection to these trials is that the exact capacity of the batteries admitted to compete was not sufficiently defined. Deteriorated plates might have been replaceable as long as any of the undestroyed original plates remained. This would have lengthened the trial enormously. The method of eliminating cells is condemned as not being employed in practice, and these eliminations should have been made during fluctuating discharges. The tests have resulted in information concerning: (1) The life to be expected from a battery up to the time when the first repairs are necessary. (2) The variation of the capacity of the battery during this life. (3) The specific factors connecting weight and output, &c., of the various types. Further details of the trials are given in pp. 211–214. [See also Abstracts Nos. 403, 952, 953, and 1349 (1900).]
M. O'G.

1963. *Method of Testing Return Circuits.* **L. Nissley.** (Street Rly. Rev. 10. pp. 149–150, March, 1900.)—In a testing car the author instals the apparatus shown in the figure. Readings are preferably taken at night so as to secure uniform conditions. The method of taking readings is as follows: The car is stopped at the place where the observations are to be taken; if at a fire hydrant, the smaller cable (not shown in the figure) is put in contact with the valve of the hydrant. Now, if the Weston ammeter indicates that current is passing, the differential ammeter is switched into circuit and the current increased by the rheostats to 20 amperes. With this current flowing from the trolley to the rail and fire hydrant, the voltage is taken and simultaneously

the reading of the differential ammeter which gives the proportionate amount of current passing into rail and hydrant.

In testing bridges, viaducts, and other conductors along the lines the exploring cable is run out and attached, the differential ammeter cut out

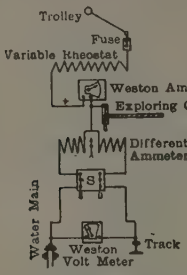


FIG. 1.

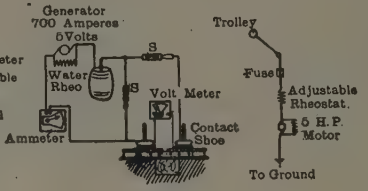


FIG. 2.

and the current increased to 500 or 600 amperes, and the drop measured. A water rheostat is used in connection with these readings to guard against the accidental burning out of the instruments. After the entire system of track has been covered by the testing car operations, and the electrical survey finished, the results should be reduced to graphic form. E. H. C.-H.

ELECTRIC LAMPS AND LIGHTING.

1964. *Incandescent Lamps.* **F. W. Willcox.** (Frank. Inst., Journ. 149. pp. 282–298, April, 353–369, May, 419–427; Discussion, pp. 427–439, June, 1900.)—This paper treats of the improvements in manufacturing and testing glow lamps up to the present time. There is nothing novel with the exception of a clever method of graphically representing the results of an initial test of a batch of lamps of the same candle power and efficiency. It is called the target diagram method. By plotting the candle power as ordinates and the watts as abscissæ, we have a graphic means of delineating accurate marksmanship (or the absence of it) in lamp manufacture. The centre of the diagram, or bull's eye, is made by the intersection of the 16 c.p. line and the 50 watt line (in the case of 16 c.p., 3·1 watt lamps). The width of the bull's eye is from the 48·5 to the 51·5 watt lines, and its depth from the 15·5 to the 16·5 c.p. lines. The corresponding dimensions of the outside of the target are from the 47 to the 53 watt lines and the 15 and 17 c.p. lines. The readings taken upon each lamp of a lot tested are plotted by placing a dot at the intersection of the corresponding watt and candle-power lines, and in this way the entire number are tested. If the lamps are good all these dots should fall within the target, and in the case of really correctly rated lamps within the bull's eye.

The author strongly advocates that lamps should be discarded when the c.p. falls to 80 per cent. of its initial value; this gives a life averaging above 400 hours for the best 3·1 watt, 100–125 volt lamps.

Discussion: **W. M. Stine** stated that the loss of candle power is due to the fact that repeated heating of the filament gradually anneals the graphitic layer of carbon formed by flashing, and brings it into a more or less amorphous state with an increased emissivity, thus lowering the temperature of the filament, and diminishing the proportion of light radiated as compared with the total energy radiated. E. C. R.

TELEGRAPHY AND TELEPHONY.

1965. *Prevention of Interception of Messages in Wireless Telegraphy.* **D. Tommasi.** (Comptes Rendus, 130. pp. 1307–1308, May 14, 1900.)—The distance at which electric waves are effective depends on the proximity of the two transmitting spheres of the oscillator. Having established communication, a second transmitter is caused to give out long and short emissions which within any zone selected will be confused with the message from the first oscillator. M. O'G.

1966. *Electrical Waves in Telegraphy.* **A. Turpain.** (Soc. Franç. Phys., Bull. 148. pp. 8–9, May 4, 1900; also Comptes Rendus, 130. pp. 1303–1305, May 14, 1900.)—Wave currents are used to speak in one direction and direct currents in the other; or intermediate stations may communicate together by direct currents on the same line as is already being used for communication between two extreme stations by wave currents. Duplex transmission and simultaneous telephony and telegraphy can also be obtained by simple means and without the use of an artificial line, thus effecting economy. To protect the insulation of the direct-current apparatus it is sufficient to enclose it in a metallic chamber. M. O'G.

1967. *Steljes Typewriting Telegraph.* (Electrician, 45. pp. 359–360, June 29, 1900.)—The features of this apparatus, as compared with the Hughes, is extreme simplicity in mechanism and action, so that it can be operated by unskilled persons. The transmitter is the ordinary A B C of Wheatstone. Upon turning the handle the armature of a simple magneto-generator is revolved and slowly alternating currents are sent to line. In the Wheatstone receiver a pointer moves to a letter on a dial corresponding to the letter in the transmitter whose key is pressed, but in the Steljes instrument a type wheel takes the place of the pointer. The escapement driving the type wheel is moved by a pair of electromagnets similar to those of a magneto-bell, the power being obtained by a weight or a spring. The type wheel is double, the rim of one disc containing thirty letters, and the other has numerals, &c. It ceases to move when the pointer on the dial of the transmitter has reached the desired letter, the current to line being at that stage automatically cut off. The type wheel is now in position to print that letter if the paper tape is brought into contact with it. The roller over which the paper passes is lifted in the following way: The line current which actuates the escapement of the type wheel also traverses a non-polarised electromagnet, and, although alternating in character, its effect upon the cores is sufficiently prolonged, while it is operating, to keep a very light armature attracted. When this drops, upon cessation of the current, it permits a cam at the end of a train of wheels to make a complete revolution. This cam, as it turns, momentarily lifts the roller and tape against the type. As the roller arm falls again a click fixed in the frame engages in a ratchet, and this turns the printing roller one space forward in readiness for the next letter. For setting all the instruments to zero there is an arm placed friction-tight on one of the wheels in the type wheel train, which is knocked down each time the printing lever is worked, so that, if the type wheels are allowed to go two or more revolutions without printing, all

the instruments will be brought to zero. There remains the device for so moving the type wheel to get letters or numerals printed, these being on the rims of different discs. A blade at right angles to the type wheel rotates with it. A light spring presses the wheel against the blade. If the zero key be depressed at the transmitter the printing lever in the receiver so influences the blade as to permit the letter band of the type wheel to print, but if the key opposite the zero key in the transmitter is depressed the blade in the receiver is pushed up, moving the type wheel forward parallel to its spindle when the numerals come into position. The apparatus has been successfully tried on circuits of various lengths and of different electrical characters.

E. O. W.

1968. *Military Telegraphs.* **P. Giron.** (Soc. Belge Élect., Bull. 17. pp. 253–261; Discussion, pp. 261–263, June, 1900.)—The author describes the modes of communication in the Belgian army and makes comparisons with those of England. The weight of the cable carried in waggons has been much reduced. It is now only 22 kg. per km. This permits of an infantry advance at the rate of 3½ km. per hour being accompanied by the telegraph. In England with very light equipment the telegraph with calvary has been run out at 12 km. per hour. Reference is chiefly made to the vibrating sounder of Cardew, with a telephone receiver, or modifications of the same. It can be worked through imperfectly insulated circuits. A case is quoted in the Soudan where it was employed on twenty-seven miles of bare wire lying upon the ground. It can also be hooked on to existing telegraph lines working on the Morse system without disturbing regular communication, a condenser or separator dividing it from the line in order to obviate a fault of derivation. Any temporary earth connection suffices. E. O. W.

1969. *Cable Signals.* **A. C. Crehore** and **G. O. Squier.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 343–388, May, 1900.)—In the ordinary system of signalling through long cables a dot is transmitted by a positive current, and a dash by a negative current. During the latter portion of each impulse it is usual to connect the cable to earth. The authors replace the battery by a drum-wound alternate-current generator designed to give successive impulses of true sine form; it is provided with a third brush which connects the middle of the armature to line. An automatic transmitter, slightly modified, with brush contacts somewhat like those of the Delaney instrument, is geared to sychronism with the generator. The paper slip of the auto-transmitter has four rows of punched holes in place of the usual three; the fourth row provides for the discharge of the cable between letters and words by connecting it to earth. With this arrangement, whenever contact is established on the dot side of the transmitter-slip, a positive sinus is sent to line; similarly, when contact is made on the dash side, a negative sinus is transmitted to line; and for all intermediate spaces the cable is connected automatically to earth through the holes in the fourth line of the slip. No sounder-transmitter or earthing device is necessary. According to Kelvin's theory of cable transmission the component corresponding to the first term of the Fourier series is the only impulse appreciable at the distant end of a long cable; hence, although the generator may not send to line a current impulse of true sine form, the received current at the far end is approximately of that form. This result was demonstrated by the authors experimentally by replacing their drum-wound generator by a shuttle-wound armature. Under these conditions the recorder signals at the distant station approached to sine forms, and at con-

stant applied E.M.F. the amplitude diminished in more or less direct proportion to the frequency. It is apparently taken for granted that the recorder signals are truly representative of the received currents. Further, the remarkable result was arrived at that the amplitude of the received signals, working duplex, within the limits of observation with a particular recorder, for a given frequency, is more or less directly proportional to the applied volts. This result will of course require further investigation before it is accepted as general. The second part of the paper deals with the theory of the measurement of current and phase and their variations with frequency. As an example the constants for the Canso-New York cable are calculated. Comparing the E.M.F.'s employed when using a battery with those of an alternator, it is pointed out that the term "equivalent voltage" requires special interpretation. The speed of signalling is not proportional to the applied volts, but it does increase with the volts; there is an upper limit, however, which, according to the authors, depends upon the dielectric strength of the guttapercha. [The authors appear to have forgotten the lightning-protector of the cable, which in practice determines, or should determine, the upper limits of dielectric strength.] It is pointed out that, whereas for air the dielectric strength is independent of the time during which the difference of potential is applied, for guttapercha and indiarubber the time element is important. When a battery is applied to a cable without condensers, the whole pressure is upon the dielectric during the entire length of a signal, but with a sine-form generator the maximum potential is momentary, and cannot be prolonged even if desired. Hence, for equivalent voltages, conditions would appear to favour the sine form. The value of the virtual alternating potential or sine-wave E.M.F. which, applied between the sending end of a cable and earth, would produce the same maximum E.M.F. at each alternation as the maximum E.M.F. applied similarly by a battery, is 70·7 per cent. of the E.M.F. of the battery. This is true whether there are sending-condensers or not. But the fundamental component of the battery impulse has a maximum much below the maximum potential of the battery; hence, for the same maximum potential at the transmitting end of a cable, the amplitude of the wave at the receiving end is greater when a sine-wave alternator is employed than when a battery is used, and more energy is transmitted at each impulse. Moreover, the secondary components of the battery impulse introduce useless static changes which have to be got rid of between each signal. In conclusion the authors describe experiments made with the apparatus, using sending-transformers, after the manner of Dearlove. R. A.

1970. *Telephony over Telegraph Lines.* **F. Walloch.** (Elektrotechn. Zeitschr. 21. pp. 237–240, March 22, 1900. Paper read before the Elektrotechniker-Verein of Hanover, Jan. 9, 1900.)—The author describes the methods adopted for enabling simultaneous telegraph and telephone messages to be transmitted over a single line, as in the Van Rysselberghe system. All these methods depend upon the use of condensers, interposed in such a way that the slow telegraphic impulses do not affect the rapid undulations of telephony. At each station, the telephone is connected between line and earth, through a condenser; and the telegraph instrument is connected between line and earth with no condenser. In practice it is found that the capacity of each condenser need not exceed 0·2 mfd., and in place of a tin-foil "plate" condenser, it is found better to use one formed of parallel insulated wires wound together on a bobbin. For this purpose the wires may be 0·1 mm. diameter copper, double-covered with silk, each of the wires having a

resistance of about 800 ohms. Plate condensers are found to transmit more loudly but less distinctly than these wire condensers. The author suggests that loudness and clearness might possibly be both attained by combining a plate condenser with a wire condenser.

The Morse-key contacts are of carbon, so as to avoid abrupt changes of current, which would affect the telephone circuit. Or a resistance bobbin may be connected permanently between the contacts of the key. In the event of there being intermediate telegraph stations between the two stations that are to communicate by telephony, each intermediate telegraph instrument should be bridged over by a condenser ; so far as the telephone circuit is concerned, this is equivalent to cutting out the resistance of all the intermediate telegraph instruments. Further, each telegraph instrument, including the terminal instruments, should be provided with an inductive resistance of about 500 ohms, to act as a choking coil for the telephonic currents. A description is given of the application of this system to the fire-alarm service in Berlin ; by means of a portable telephone apparatus communication can be made with the central fire station from any of the 800 fire-alarm posts.

R. A.

1971. *A Telephone Experiment.* **E. Piérard.** (Électricien, 19. pp. 309–311, May 19, 1900.)—The author recapitulates the experiments referred to in Abstract No. 1226 (1900), and describes how the "singing condenser" is operated. A vibrater, before described, is put in circuit with a battery and the primary of an induction coil. In the secondary circuit is a condenser formed of sheets of tin-foil in size a square decimetre, separated by paper. When the vibrater is sung to, the condenser reproduces the melody more or less strongly according to the power of the battery. E. O. W.

1972. *Telephone Switchboards.* **J. Anizan.** (Journ. Télégraph. 24. pp. 97–102, May, 1900.)—The author describes the arrangements in force in small telephone exchanges in France where from 10 to 500 subscribers have to be provided for. There are four types of board with the usual fittings, for 10, 25, 50, and 100 lines. The first is fixed to the wall, the others stand in cabinets in the usual way. When extensions are required, another board of the same type is set up side by side with the first, and connections can be made across to the various subscribers either with the ordinary cords and plugs if long enough, or through the service or local jacks. There is an arrangement by which, during busy hours, the 100-line board can be worked by two operators. In all the exchanges, except for 10-line, the lines are brought first to distribution boards, furnished with carbon plate lightning protectors. The connections behind the switchboards are so made that jacks and annunciators can be withdrawn for repair or adjustment without detaching the wires. The microphone of the operator is furnished with two batteries for greater security in working, either of which can be plugged in or out by a switch. E. O. W.

1973. *Poulsen Telegraphone.* **J. Blondin.** (Écl. Électr. 28. pp. 397–408, June 16, 1900.)—This instrument differs from the phonograph in important particulars. It can transmit to a distant telephone receiver the sounds which it has registered. It can also register the sounds received from a distant telephonic transmitter. The currents to be registered are led to a small electromagnet, between the poles of which glides rapidly a wire or tape of steel. The wire may be 1 mm. in diameter, and the tape proportionately

wide, and move at a rate of 36 metres per minute. The variable magnetic field developed between the poles of the electromagnet produces a magnetisation of the wire or tape varying with the field. Each point of the wire or tape after passing the poles possesses a transversal magnetisation of which the intensity depends upon that of the telephonic current creating the field. Words spoken at the place of origin are thus inscribed upon the wire or tape. If the electromagnet is connected with a telephone receiver, and the tape or ribbon caused to pass its poles with the same speed and the same direction as before, the cores of the electromagnet are now affected by the variation in intensity of the magnetisation of the wire or tape, currents are thereby engendered in the bobbin, and the telephone reproduces the original speech. The steel wire or tape thus forms a record of any conversation. In the reproduction the metallic timbre of the phonograph is absent. An inscription can be cleaned off by exciting the electromagnet with a current of suitable strength and drawing the wire or tape between its poles. The wire or tape is then ready for further use.

Two forms of the apparatus are described at length with details and sketches of the various parts. One is for short conversations of one or two minutes, the other for longer records. Both are started automatically by currents from the distant station, and are arrested when the conversation or message is finished.

In the first instrument described the wire is wound upon a drum driven by a little electric motor. The drum is vertical. During the time of operation a little electromagnet which receives the currents, which rides upon a carriage sliding upon an upright, presses with its poles upon the wire, and during the revolution of the drum follows the winding of the wire, being carried vertically up its support. Upon arriving at the top the carriage comes into contact with a stud, opening the circuit, stopping the movement, and falling down to its original starting place. The mode of governing and attachment of the connecting wires is described, as also the way of joining up the instrument in conjunction with, or separately from, a telephone, either a transmitter or receiver.

The other instrument contains a long tape for registration of more lengthy communications. The tape is wound upon two flanged wheels revolving in the same vertical plane and opposite to each other so that the tape can pass from one to the other wheel or *vice versa* by altering the position of a little friction roller which actuates the wheels when driven by an electric motor. A relay as before receives the starting current from the distant station, and an electromagnet in the local circuit is caused to attract an armature and to put the machine in motion. The little electromagnet which communicates variation in intensity to the tape rides horizontally upon it between the two vertical tape wheels. The tape can be wound forwards or backwards, and can receive or transmit a message. The impressions can be effaced as previously described. Poulsen has devised three methods of reinforcing the sounds obtainable from the steel wires or tapes. The first is by arranging a series of electromagnets at equal intervals in a line, their lower poles being in contact with a similar number of horizontal steel wires arranged at equal distances vertically below, the points of contact being on one and the same diagonal line. The wire containing the record is made to travel along the upper poles successively of the electromagnets, at the same time all the other wires below are made to move at the same speed in the same horizontal direction, thus carrying with them by the action of their own magnets a facsimile of the original record. Although the magnets succeed each other

at equal intervals, the points of contact below on the wires are spaced also at equal diagonal distances, so for any given vibration or magnetic "stain" upon the original wires or tape, all the reproductions will arrive simultaneously in one vertical line during the travel of the wires. In such a vertical line are arranged a series of electromagnets, across the poles of each of which passes one of the wires. The receiving telephone is in circuit with this series, and the sounds are magnified to an extent corresponding to the number of magnets used.

The second plan is to stretch a wire parallel to the first, which contains or is receiving a magnetic record, to cause the first to pass successively across the upper ends of cores of a row of electromagnets, and the second to pass similarly across the lower ends. It is claimed that the original magnetic "stain" becomes deepened, by induction, upon the second wire, and that if this be now employed to reproduce a message the sounds are louder.

The third method of reinforcement of the sound is to cause the wire possessing the record to travel more quickly across the poles of the reproducing electromagnet. The inventor finds that at a speed of 30 metres per second a sound communicated originally in a low voice to the microphone is intensified to a disagreeably high degree.

In this last manner the construction of a telephonic relay is possible, for the wheel containing the wire or tape record, on receiving it from any station, can be driven at any desired speed, and by suitable arrangement of auxiliary electromagnets, can retransmit the sounds thus reinforced to another or several other stations.

Finally, two or more communications can be superposed upon one and the same wire or tape by connecting up and winding the inscribing electromagnets in different ways. To read off the inscriptions separately the reproducing magnets must be wound and connected appropriately. Thus duplex and multiple telephony is realised. E. O. W.

1974. *Hoar Frost on Telephone Wires.* **E. Piérard.** (Électricien, 19. pp. 232–234, April 14, 1900.)—Hoar frost may be removed by a blow, particularly from distribution centres. It is mathematically deduced that long stretches of wire are not a drawback with bronze of high tensile strength, but that with ordinary telegraph wires one hundred metres should be the normal limit. M. O'G.

1975. *Submarine Cable-hooks.* (Électricien, 19. pp. 225–227, April 14, 1900.)—A special grappler by Rouillard avoids the usual multiple hooks, and provides one only which is kept at right angles to the sea-bottom. For rocky bottoms a centipede is employed with teeth in pairs at right angles to one another. To prevent the teeth from grasping the rock, a counter-tooth of opposite curvature is placed within each tooth, the distance between the teeth being, however, sufficient to admit the entry of the cable. M. O'G.

REFERENCE.

1976. *Telephone Exchange.* **H. E. Hall.** (Elect. World and Engineer, 35. pp. 355–358, March 10, 1900.)—Description of Walnut Hills Exchange, Cincinatti, Common Battery System, 4-Party Line, described in outline and illustrated by diagrams. J. E. K.